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ABSTRACT

This volume presents three analytical discussions of issues in the application of technology at the postsecondary level, both in the provision of distance education and its use in support of teaching, learning, research, administration, management, and libraries in institutions of higher education institutions. Part 1, "Responding to the Triple Challenge Facing Post-Secondary Education: Accessibility, Quality, Costs" (by Stephen Ehrmann) offers an overview of how technology can meet these challenges suggesting types of instructional arrangements and the infrastructure needed to support such arrangements. Part 2, "The Future of Face-to-Face and Distance Teaching in Post-Secondary Education" (by William Renwick) focuses on the impact of technology on these two modes of education and the new interrelationships between them. It discusses institutional responses to rapidly changing demands and expectations by universities, polytechnics, colleges, and others in European nations. Part 3, by Gordon Bull, "Student Owned Computing: The Issues for Higher Education Management" raises issues (academic, resources, human and social) to which higher education institutions are confronted when students themselves are well equipped with new information technology. These include cost to the student, cost to the institution of supporting infrastructure, the need for standards, and the role of network services. (Contains 43 references.) (DB)

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Information Technology and the Future of Post-secondary Education

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FOREWORD

Most OECD countries are today faced with rapid economic, technical and socio-cultural changes leading to growing demands for education and training in the context of lifelong learning. Post-secondary education institutions are increasingly affected and caught in these changes. They must develop systems of post-secondary education and training for an ever growing number of students and develop much more attention in future than they have in the past to lifelong learning, second-chance education, and on training initiative together with industry.

As most Member countries are experiencing increasing student demands in their post-secondary sectors, many start to realise that they cannot meet this challenge by only extending the conventional face-to-face and institutionally-based learning system. Therefore many institutions and countries lay down at stakes on information and communication technology which seems to be the most promising tools providing a high-quality education more suitable for the 21st century. Such tools, it is claimed, would be more capable of responding to much more diversified demand from different categories of students.

Over the years, both the Centre for Educational Research and Innovation (CERI) and the Programme for Institutional Management in Higher Education (IMHE) of the OECD have undertaken several activities aiming at a better understanding of impact from information and communication technology on post-secondary education and likely future developments.

CERI's work has focused on the improvements for learning with new technologies in conventional face-to-face education and the way they also change distance education delivery modes. This work has made it clear that the border-lines between distance education and traditional face-to-face education are being blurred because of the massive diffusion and penetration of new information technologies. IMHE which is concerned with strategic management of higher education institutions, has concentrated on the developments and use of information technology in support of teaching and learning, research, administration, management, and libraries in higher education institutions.

This joint CERI/IMHE publication which is based upon the above-mentioned CERI and IMHE work includes three main analytical contributions. The first, by Stephen Ehrmann, Senior Program Officer, the Annenberg/Corporation for Public Broadcasting Projects, Washington, DC, United States, presents an overview on how technology can meet the triple challenge of access, quality and costs in higher education. The second by William Renwick, Honorary Senior Research Fellow, Victoria University of Wellington, New Zealand, focuses on the impact of technology on face-to-face and distance education and the new interrelationships of these two modes of education, and the third contribution, by Gordon Bull, Professor, University of Brighton, United Kingdom, raises major issues (academic, resources, human and social) to which higher education institutions are confronted when students themselves are well equipped with new information technology.

This document is published on the responsibility of the Secretary-General of the OECD.

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Part I

RESPONDING TO THE TRIPLE CHALLENGE FACING POST-SECONDARY EDUCATION: ACCESSIBILITY, QUALITY, COSTS

by Stephen C. Ehrmann
The Annenberg Corporation for Public Broadcasting Projects
Washington, DC, United States

INTRODUCTION

Institutions of post-secondary education, and those who pay for them, face three daunting challenges, each of which makes the other two more difficult to resolve:

- accessibility, especially how to reach and educate the full range of adults who deserve a chance at an education, despite their location, schedules, cultural differences or physical disabilities;

- quality, especially learning for the 21st century: how to improve the life chances of each of their adult learners, as individuals and as members of economic, cultural and political communities; and

- costs, especially the costs of achieving the first two objectives in the face of slow economic growth and other urgent social needs.

This triple challenge is forcing government officials and academic leaders to face troubling questions such as these:

- Can high-quality courses of study be offered at reasonable costs for large numbers of adults if one adds a few "innovative" programmes to otherwise unchanged institutions, perhaps while eliminating or expanding a few existing programmes?

- If the answer to the above question is "no" and it is necessary to take a deeper and more searching look at the assumptions that govern today's systems of post-secondary education, are there lessons that the best campuses can teach distance and open learning programmes? Are there lessons that the best distance and open learning programmes can teach campuses? Will it be necessary to leave traditional definitions such as "campus", "distance" and "open learning" behind and restructure post-secondary education?

If not met, this triple challenge will lead to a gradual deterioration institutionally and nationally. Those institutions that do not respond may find it harder and harder to find support for even their most central functions. Those countries that do not respond may find it more and more difficult to educate their citizens and maintain a vital national economy and life. And a world where too many countries fail in their educational responsibilities will become an increasingly dangerous place. In short, those who fail to respond have much to lose, and those who respond creatively and successfully have much to gain.

This report is written for those leaders who face choices about whether and how to restructure post-secondary education in their countries. It describes a few concepts and examples that may help make sense of a seeming chaos of problems and possibilities.

The first section of this part takes a closer look at the triple challenge. Later sections lay the foundation for considering what types of arrangements for teaching and learning might be most helpful in meeting the triple challenge and what sorts of infrastructure are necessary to support those arrangements.

1. The triple challenge

Challenge 1: Full and equitable access

In many countries, the pool of potential learners has grown faster than education budgets. There are many barriers to access:

- More of the adults who need post-secondary learning have different schedules from traditional teaching institutions and from one another due to family and work responsibilities.

- They may be distant from a campus offering the academic programme they need and may live in rural areas where there is no post-secondary institution at all.

- They may not be fluent speakers of the national language of the country where they are living.

- Their learning style may not be a good match for the particular type of education offered them. For example, they may be offered only an opportunity to study at a distance from campus, alone, when they need more contact with other learners. They may need visual materials in a course of study that relies mainly on text.

- Many are physically challenged in ways that, in previous years, would have led to a wasting of their talents; that is no longer a tenable position and, in some countries, it is no longer legal.

- A number have had poor experiences in earlier schooling and are thus intimidated by the forms of post-secondary education.

In the United States, for example, where the pool of 18-year-olds shrank during the 1980s, there is now a "New Majority" of undergraduate learners who are not going directly from high school through a full-time post-secondary education to a two- or four-year degree (Pew Higher Education Research Program, 1990). The same thing is true in many other countries. Still, more adults are unable to enrol at all due to such barriers.

Terms such as "non-traditional learner" tend to blame the victim, assuming that there is nothing that post-secondary education can do for these marginal learners. However, the problem is not simply one of disadvantage (a label that points the finger of responsibility and blame at the learner and the learner's home community), but of accessibility. Imagine a school with doorways 1.3 meters high. It would soon have two populations of students: normal students and head-injured (non-traditional) students, otherwise (privately) called "weeds". Some faculty would believe in providing each weed with a raft of compensatory medical and educational services, while other instructors

would argue that this special treatment would be unfair to normal students (those who coincidentally were less than 1.3 meters tall). Both groups might take awhile to notice that there is a third option: invest in raising the height of the doorways. Once done, and after the brain-damaged weeds graduate, there would be only one type of student: normal.

The "low doorway" of the traditional academic programme is the fact that students who can afford to come within the campus walls and study full time can get access to a better education than students who cannot. The next section considers how that situation came to be and how it is changing.

Challenge 2: Educating adults for the 21st century

Today's and tomorrow's adult learners will spend their lives in the 21st century and will need somewhat different knowledge and skills to do so. The growth of on-line library systems gives a physical representation to the dizzying growth of accessible information. In developed countries, it is commonplace to remark that adults will have four or five careers in their lifetimes, sometimes because their previous job has disappeared. Among the skills likely to be of increased importance in the next century:

- The ability to frame problems when facing unfamiliar situations. Tomorrow's problems may be similar to yesterday's once they are well understood but they will present themselves in mysterious forms. Once a problem has been framed, it must then be solved. Increasingly often, both the framing and solving of problems will require the use of powerful information technologies. Framing and solving problems will sometimes be simpler, often more difficult than before.

- The ability to communicate, especially with people from other cultures. Cultural differences are increasingly salient, within as well as between countries. Yet without certain common values and shared insights, political and social life becomes impossible, and conflict and human waste on a grand scale result.

- The ability to work in, form and lead teams and coalitions, once again including people from cultures other than one's own. This vital skill has seldom been taught thoroughly in schools or universities, yet research indicates that it is already one of the most important capabilities in the workplace (Klemp, 1977; Boyatzis, 1982). As interdependence increases, collaboration, like communication, will become even more universally important.

- The ability to identify what needs to be learned, and then efficiently learn it. Modern information technology will often furnish the means for learning. And every educated person will need to spend a certain fraction of his or her life keeping up with changes in that technology.

In all these areas what is essential is what Entwhistle has called "deep learning": in deep learning the student actively relates what is being learned to previous knowledge and experience, searching for patterns and underlying principles while continually checking evidence and relating it to emerging conclusions. Deep learning is surprisingly difficult to foster; research indicates that even students who get excellent grades often fail to understand seemingly simple science ideas that are the heart of the material that they have supposedly mastered.

Challenge 3: Control of costs per graduate[1]

Economies are growing quite slowly. Meanwhile, the compelling demands of other sectors such as health care and support for the aged are growing swiftly, faster than the growth of economies or population. The result has been a bind for post-secondary education: the demands on it to help heal and fuel national economies have increased but funds available to meet those educational needs are quite limited. In most countries, the costs of educating a sufficient number of adults are seen as difficult or even impossible to meet and the costs are growing. Controlling costs by cutting access or by degrading the quality of education is no answer.

There is no easy way out of this bind, and this report will not recommend a technological panacea. In fact the need to invest a significant fraction of the post-secondary budget in technology means that computing, video and telecommunication can be seen as part of the problem. This report will suggest several ways of shaping that investment so that technology is also part of an effective response to the triple challenge.

2. A moment in history: challenging the ideal of campus-bound learning

No one denies that the possibilities offered by new technology to education are bewilderingly numerous, rapidly changing and sometimes difficult to understand (by the time many of us understand a new technology it may have already become obsolete!). In such circumstances, it helps first to look backward and consider what the essential elements of learning have always been. With a foundation in the history of education, one can then look to the future and pointed questions about the facets of learning that any new technology must be able to support. Thus the next section of this report briefly describes traditional *technologies* of education, *i.e.* the physical and organisational means by which education has been provided.

In most countries people may look at campus buildings and say "There's the university". They may look at a lecturer, and say "There's education". Why do they think so? When did these perceptions begin?

The cave and the campus

It is said that the first user of educational technology was a cave dweller named Thok. Thok was a bit better than average in survival skills, so curious cave people would bring gifts of food and clothing to Thok's cave and then ask questions about how to survive. They would talk in small groups, much as Plato and his students would do so many years later in the grove of Academe.

Being a good teacher, Thok learned as much from these "students" as they did from their teacher. Year by year, the crowds of students at the mouth of Thok's cave grew. Their teacher, fed by their gifts and thus not leading the hazardous life of a hunter-gatherer, grew ever wiser but ever more elderly. Finally Thok's failing voice could no longer be heard by those at the edge of the crowd. Thok then had an idea of historic dimension, folding a banana leaf into the shape of what today would be called a megaphone. With the aid of this technology, many more distant learners could learn from Thok.

Nor was educational technology the only craft invented on that day. Some in the crowd doubted the value of megaphonology. To test the teaching power of banana leaves, one of the cave people began walking around with a leaf on his head. Learning nothing, this first of all evaluators concluded that megaphonology was of no educational value[2].

For a long time learning resources such as manuscripts and smart people were as scattered as caves. Since these human and material resources were scarce, fragile in a violent time, and, in their own way, costly, educators had the bright idea of collecting them in a protected environment. Caves in due course gave way to cloistered libraries and campuses. Campuses also made sense because books and scholars could only be used by a few students at a time and, of course, only if the students came to the same place where the book or scholar was. At that time, and for centuries thereafter, that was the only sensible way to organise an education. This sense of a small, protected oasis of human and material resources in the midst of an intellectual desert may have given rise to Dean Julius Caesar's famous comment: "All the world is divided into two parts, on-campus and off-campus."

The campus was not so very different from the cave: safe, intimate with limited admission. The campus was also, like Thok's banana leaf, a technology designed to increase access to education and also to improve the quality of that education. Comparable inventions have become prominent elements of modern education: the printed book and the lecture hall. All these technologies make it possible for a teacher to provide directed instruction for more people than he or she could meet in an intimate cave or seminar room. The printed book was a particularly important advance because it meant that the teacher's message could reach across hundreds of miles and years, transcending even the death of the teacher. For the student, it meant access to even more teachers and to primary source material, too. Some people tend to approach the challenge of educational productivity rather simple-mindedly in terms of staff-student ratios. But notice that the advent of the printed book cut staff-student ratios (by expanding the number of teachers each student could reach) while simultaneously increasing the staff-student ratio (by expanding the number of students each teacher could reach).

People no longer argue with one another about whether the best medium of education is conversation in a grove of trees or reading a printed book. But they do have disagreements about quality in education. Before this report can discuss options for restructuring education, it must first revisit some of the basic disagreements about the definition of "high quality" learning.

Definitions of quality in post-secondary education

Quality should ultimately be measured by studying who begins and completes a course of study (access), the success of graduates in making a life for themselves and their communities (quality), and the efficiency of their education in light of that success (cost-effectiveness).

Because such studies are difficult and the results not available until long after they have ceased to have practical value, however, educators and governments often turn to a more process-centred way of gauging quality. There are at least three distinctly different ways of looking at the quality of the educational process.

Definition 1: Quality of education is defined by the quantity and quality of the institution's academic resources

Thus, by definition, the institutions richest in resources provide the best education. Traditionally, the institution owns its resources and keeps them within its walls: its full-time faculty, the books on its shelves, its laboratory equipment and so on. The institutions with the richest endowments are, by this definition, the best institutions. This is a convenient way to measure quality since resources are available for inspection by all.

Definition 2: Quality is defined by selectivity (exclusion)

Those institutions that bring the fewest students into contact with their resources are the best institutions. This definition springs in part from the fact that traditional technologies of education -- the libraries, the laboratories, the faculty themselves -- can be used by only a few people at a time. People using this definition sometimes also include the student body as a resource, assuming that a major value of the institution lies either in the intellectual stimulation of a bright student body or the social value of a well-connected one.

When only a few people can use any educational resource at one time, policy makers face a difficult choice. If they make institutions selective, a few students get a good education and no one else gets one at all. If they expand education, the result is mediocrity by this definition. Many countries choose both options and have a dual-track system, reserving the best of the resources for a few students and spreading the rest thinly among a large number of other students who are judged less deserving.

Definition 3: Quality is defined by the silent, critical, creative conversation within the learner's mind that is spurred and supported by the learning environment

This is an extension of *Definition 1*. The value of the resources is determined not by their cost, however, but by the ways in which they stimulate reflection and learning. The technologies of education can be divided into four groups, each supporting a different type of *interaction* between the student and the academic programme[1].

- *Conversing* with faculty, students and distant experts *in real-time*. In campus-bound institutions, real-time conversation is supported by the technology of the campus itself, which assures that all the conversational partners can easily be brought together. Other traditional technologies supporting real-time conversation include seminar rooms, the instructor's office and informal gathering places.

- Exchanging ideas and materials with faculty, students and others over a period of hours and days *("time-delayed conversation")* usually through the exchange of homework. This exchange is also facilitated by the compact campus community.

- The single learner's interaction with textbooks, lectures, videotapes and other *directed instruction* about the content of the course; these materials and messages are typically "broadcast", *i.e.* sent from one point to many students.

- *Learning by doing*: by using tools and resources that are the same as, or similar to, those of the professional: the typewriter, the research library, the laboratory, the studio.

Now that these three contrasting definitions of quality have been clarified, the report can return to the issue of quality in open, distance learning and campus-based learning in recent decades.

The rise of distance learning

Thok's banana leaf, the lecture hall and the printed book made it important that students spend at least some of their study time away from their primary teachers, sometimes in the back row, sometimes in the library or in their rooms. That's "distance learning", a term ordinarily applied only to programmes in which the student has little or no contact with the instructor and ordinarily assumed to be inferior to "face-to-face learning". Yet, distance from a single master can create higher quality learning when that distance enables students to interact with more experts (some through the books they have written) and more peers and to spend more time in learning by doing. Such distance also frees the instructor to work with more students (increasing both accessibility and cost-effectiveness).

Distance learning became a significant enterprise with its own organisational identity when print duplication became less expensive and the demands for adult learning outstripped the ability of the society to build campuses. Unfortunately, these early forms of distance learning (called "correspondence learning" in some countries) could be usually classified as low quality by all three definitions:

- *Definition 1:* the rich resources of the campus, such as the library, were usually not available to the distant learner.

- *Definition 2:* correspondence was not usually exclusive -- quite the contrary, it was intended to include students who could not attain an education any other way.

- *Definition 3:* of the four forms of interaction, correspondence emphasized only one: the student's thoughtful interaction with the instructional message (the print materials). The learner was relatively isolated from other people (real-time and time-delayed exchange), and there was little work in the laboratory, research library or studio (learning by doing).

Open learning

The term "open learning" is applied to a variety of related forms of learning and will not be described in detail here. Like "distance learning", the term is usually meant to offer a contrast to "traditional" campus-based programmes, denoting programmes that place certain fundamental choices in the hands of each learner. For example such programmes are less constrained in schedule, tempo, modes of assessment or location of study. In recent years, some open and some distance learning programmes have begun to look even more alike, with each providing adults with relatively self-contained bodies of learning resources through academic programmes that are organisationally separated from "normal" education.

In the 1970s and 1980s, some institutions and countries began to strengthen the quality of distance and open learning by investing in providing richer instructional resources (*i.e.* using *definition 1*). Sometimes this investment took the form of the creation of open universities that

created and then offered well-structured courses to large numbers of students studying at a distance. In the United States, many institutions were already serving the New Majority with on-campus and locally produced distance learning programmes. Progress was accelerated by a major private gift. Inspired by what he had seen of the Open University while Ambassador to Great Britain, Walter Annenberg made a grant of $84 million to the Corporation for Public Broadcasting to create the Annenberg/CPB Project. Aided by further funding, the Project was able to create packages of video and print materials costing as much as $7 million per course to develop. Their pedagogy was innovative. For example, packages teaching second languages relied on an inductive approach and helped students gain insight into a new culture by using engaging video-based stories produced in the countries under study. Annenberg/CPB Project science courses illuminate the history and applications of science, and display natural phenomena that occur on scales far beyond the scope of traditional laboratory demonstrations. In short, use of video made it possible to provide students with vivid, multi-faceted learning materials that were better than almost any campus could provide unaided. As a result, thousands of institutions in the United States and in approximately eighty other countries began using these course materials on campus, even at highly selective institutions, and for distant learners.

The ideal of campus-bound learning

Ever since the days of Thok, as technology's limitations forced education into the cave of the campus, educators have made a virtue of necessity, and made an ideal of campus-bound learning. The best university was presumed to be the one that owned the most and best resources (including faculty) and had the best students within its walls. What was outside its walls did not matter.

The success of the best open universities and of the Annenberg/CPB Project, not to mention technologies of resource sharing pioneered by printed books, interlibrary loan and time-shared computing, raise real questions about whether *Definition 2* (quality as exclusivity) and the ideal of campus-bound learning are still defensible. Modern video and print duplication, and video broadcast, made it possible for large numbers of learners to profit from the same instructional resources at the same time. But questions about quality could still be raised by *Definition 3* since the Annenberg materials and others like them emphasized directed instruction, not learning by doing, real-time conversation or time-delayed conversation.

Fortunately, the late 1980s and early 1990s were also a period in which new technologies also began to strengthen those other three facets of the learning process. The next section will examine how technology can improve both quality and accessibility in all four facets of the learning process.

3. Using today's technology to support high quality courses of study and student services

The predictable improvement in digital technology (sometimes estimated to be an improvement of 20 per cent in price-performance per year) enables periodic, unpredictable and often surprising changes in the ways educators can support the four dimensions of interaction.

The sheer unexpectedness and excitement of new technology tends to draw all eyes to itself. It tends to focus discussion around the newest technology and the quest to discover what it can do best. For educators this is usually a mistake. *One cannot build cutting edge education on cutting edge technology.* Cutting edge technology is ordinarily too expensive (relative to its lesser price several years later), too brittle and too difficult to learn to use. That's the bad news.

The good news is that through extensive use in and outside education, the newest applications of computing, video and telecommunications become affordable, reliable, familiar (almost to the point of invisibility) and invaluable. Every year, more and better technologies become available for use as part of cutting edge education (some years after they are first used in other sectors).

Thus, it was that by 1990 changes in educational practice demonstrated concretely that a technological threshold had been reached and passed in at least some countries: educators could now enrich and extend each of the four dimensions of interaction.

Real-time conversation within a small group

Real-time conversation among students, between the student and the instructor, and between the student and an external expert is uniquely useful for coaching as the student develops new skills and for brainstorming. For those who doubt the importance of real-time conversation in learning, try the following experiment with a partner:

- Each of you take a paper and pencil and sit back to back so neither of you can see the other's paper.

- Your partner should draw a simple figure on a piece of paper, using no more than seven straight lines.

- Your partner should orally instruct you in how to draw the identical figure. You are NOT allowed to ask questions, nor to turn around to see your partner's drawing, nor can your partner look at your drawing. Time how long it takes you to draw the figure and grade yourself for accuracy once you are finished.

- Now sit face to face so that you can see one another's drawings, allow speaking and repeat the experiment. In which experiment did you learn more quickly and correctly how to draw your partner's figure? This is a simple and powerful demonstration of the difference between one-way instruction (directed instruction) and real-time interaction in a small group.

This simple exercise is complemented by a vast body of research on the instructional power of collaborative learning.

Audio conferencing is still the most flexible, least expensive way to support real-time interaction among people in different places. Any telephone provides a point of entry to the conversation. Students, faculty and "visiting" experts can usually participate from their homes, offices or nearby educational facilities.

Audiographic conferencing has been used in distance learning for some time in Canada, the United States and other countries. Using one or two telephone lines, an ISDN line, or a high-speed connection, widely separated faculty and students can talk while seeing the same text and graphics on their computer screens. The visual side of this technology is also sometimes called a "shared white board". In a calculus course, for example, anyone in the class can:

- display an equation representing an action shown in a video image (both of which are displayed almost instantly on everyone's computers);
- draw a graph representing the equation (which then also appears on each screen); and
- ask a question about the image via audio hook-up while pointing to that segment of the image (everyone sees a cursor move to that point on their screens).

There are different types of audiographic conferencing systems. Most allow the sharing of images. Some enable two or more people to work on a piece of software together. These systems can be used for tutoring, enabling the distant tutor to "reach over the student's shoulder", to demonstrate a programme feature or to modify the student's work, and for collaborative work on a shared project such as a spreadsheet, graphic image or piece of music.

Real-time writing: It is also possible to converse by computer alone if the participants type their conversation instead of speaking. Such arrangements are sometimes used in composition classes. As one student in such a course remarked, "after a while, I forgot I was writing". That's one purpose of this teaching: to provide a bridge between the unconscious ease of informal conversation and the new language of formal written conversation. Too many students see the written word as an exercise to satisfy a teacher; real-time writing helps break down that perception.

Northern Virginia Community College in the United States used real-time writing to create interaction among two relatively homogenous but very different groups of students on two of its campuses: one group lived in a rural area while the other lived near a military base. The instructor made use of the differences and friction between the two groups to create the energy for her composition class (Bruce, Peyton and Batson, 1993).

Two-way video is occasionally used for small group conversation, but it is rarely affordable for applications requiring large numbers of such conversations; one exception is when time is quite valuable, resolution of ambiguity is important, and the visual dimension is crucial. Certain medical applications fill this bill, for example, some of which have been tested as part of DELTA in Europe.

Time-delayed conversation within a small group

In traditional settings time-delayed conversation is carried out through the exchange of homework, a slow process at best. Homework exchange can seem impoverished because it typically is limited to three conversational turns:

- The instructor poses a question (a task).
- The student responds.

- The instructor responds some time later with a grade. That usually ends the conversation, because grades can be conversation-stoppers, but also because, by the time the grade is received, the course has often gone on to new topics.

Using technologies such as electronic mail, time-delayed exchange can proceed in a rhythm of hours rather than days or weeks and, thus, can support a wider variety of instructional purposes, for example, a more thoughtful, slower-paced form of brainstorming, role playing simulations, student communication about projects they are doing together. The learner can receive feedback when it is still meaningful.

While electronic mail and computer conferencing are still often restricted to the text medium, each year there are more systems operating on high-speed networks with a user-friendly capacity to send and receive any digital information (spreadsheets, formatted documents, images and so on).

Computer conferencing, if used as a primary medium of exchange in classes, can extend and enrich teaching (even for students on-campus) by:

- opening classes to people with varying schedules, because each person can log on and review recent conversation whenever they like;

- opening classes to people who are not in the same place at the same time, because each person can log on from wherever they find a computer and modem; in an institution with commuting or working students, this may be key to making possible group work by students who too rarely can meet together after class;

- opening classes to people with accents that would interfere with communication if they had to rely solely on oral conversation (Hiltz, 1989) because participants can take as long as they want in order to study the (written) contributions of others and then to compose their own responses;

- helping students who, for other reasons, may learn better if they have the option to listen deliberately and respond deliberately;

- enabling faculty and students to use more collaborative forms of learning since the instructor's profile is lower in a conferencing environment: he or she, as just one more line of text on the screen, can avoid unintentionally dominating or squelching student discussion; and

- helping students feel in touch with fellow students and faculty and less isolated.

One of the more suggestive pieces of research about the educational implications of computer conferencing analysed a class studying a second language. Students used computer conferencing and electronic mail to converse in the language they were studying, while the control group used a conventional audio-based language laboratory. The research showed, among other things, that the oral performance of the experimental group was superior. Apparently students from the control group, when asked to perform orally in class, had to worry about their accent, their speed of response, and, of course, how they were to express themselves. This probably rendered them less adept at expressing themselves orally and spontaneously in the second language. By contrast, the experimental group had plenty of practice expressing themselves in the new language as they planned

parties, talked about topics due to come up in class and helped one another through the rough spots. For these reasons, the experimental group outperformed the control group (Smith, 1990). Virtually any new subject area is, in effect, a new language for the learner. Whether learning to express thought in a literary essay or in algebraic equations, students may benefit by practising by conversing with one another in their new language through electronic mail.

The power of computer conferencing and electronic mail is also signalled by a recent evaluation of a set of virtual colleges and universities in the United States. In 1990, the Annenberg/CPB Project helped these institutions begin to offer "New Pathways to a Degree" that were supported in these four dimensions of interaction. An external evaluation investigated faculty and student assessments of the various types of real-time and time-delayed communication. Students studying off-campus and their instructors each compared the technologies they used to face-to-face communication on campus. A large majority of students and faculty agreed that electronic mail provided communication that was the same or better than on-campus communication in its frequency and its usefulness (Markwood and Johnstone, 1994, pp. 140 - 144).

As global use of electronic mail increases, small group conversations can include widely-scattered participants. Collegial exchanges and expert consultations can occur inexpensively across national boundaries and time zones.

Although electronic mail and computer conferencing are the most widely used technologies for distance learning, fax is also in common use to support conversations in many countries, especially for the exchange of homework. There is growing interest in the use of voice mail also. Modern digital systems enable faculty to create "mailboxes" for each student. For example, students learning a second language call their mailbox and record their homework; later the instructor calls the mailbox, listens to the student's recitation, gives feedback, and then listens to the next student's recorded homework (see Annenberg/CPB Project, 1992, in the bibliography).

Tools and resources for learning by doing

Some of the most important and enduring learning is done when the student works more or less as an apprentice: carrying out complex tasks similar to those that he or she will perform after graduation. These tasks will be as varied as the aims of a post-secondary education. Because many of them require technology, old or new, after graduation, learning the tasks usually requires technology, too. Sometimes the technology is as simple as a pencil and paper for writing a poem. Sometimes more is required.

Modern technologies offer cost-effective possibilities for learning by doing because machines such as computers and VCRs can be used in so many courses by changing their software. High-speed computer networks offer access to even more varied tools and resources. Global internetworking is expanding so rapidly that each day sees the addition of new archives, computer-based tools and human resources. The World Wide Web of information resources, initially created in Switzerland, is a hypertext of interconnected texts, images and computer-based capabilities such as simulations.

Once again the old "either access or quality" trade-off is transcended. Learning by doing can be both enriched and extended when widely scattered learners have access to basic hardware and software, either directly or by network connection. Of particular use is worldware: hardware and software originally designed and marketed for purposes other than instruction. In many countries

worldware is used more often for instruction than is courseware specifically designed for instructional use. The most common types of worldware are familiar to all: word processors, spreadsheets, statistical packages and the Internet itself. Also in frequent use are more specialised types of software such as computer-aided design software, music synthesisers and molecular modelling packages (Morris *et al.*, 1994). These tools and resources are cost effective for several reasons:

Instructional Functions and Technologies

Technologies supporting student engagement in	Older Technologies	Newer Technologies
Live conversation Functions include coaching, brainstorming	Seminar room with. round table, blackboard Residential campus (make it easy to run into people)	Audio conferencing Audiographic conferencing 1-way live video with audio talkback; 2 way video "Chat" & other real time writing
Time-delayed conversation Function: reflective conversation and other exchanges requiring investment of time during the exchange	Residential campus (makes it easier to exchange homework) Mail, regular and express	Fax E-mail and computer conferencing Videotape (*e.g.* of student performance and faculty critique)
Learning by doing Function is to learn the skills of a graduate by creatively practising those skills, using the tools and resources similar to those to be used later	Typewriter Library (research material) Laboratory Studio Internship programme	Computer for designing, composing, simulating, and analysing experimental results Use of authentic video from a foreign country to study that country's language, culture On-line use of distant libraries, computer-based research tools, and data
Directed instruction Functions include explaining and demonstrating	Lecture hall Slide projector Textbook	Live and taped video Computer tutorial, drill

- Whether worldware is developed for (well-funded) faculty research or (lucrative) business applications, multiple producers are probably racing with one another to produce faster, more powerful, less expensive packages that run on multiple platforms. New versions will usually run files from older versions and even from competitor's packages. Instructional staff can be relatively confident that, if they invest time in rethinking portions of a course to take advantage of worldware, they can use the new course materials for as long as they choose, even as computers and operating systems change.

- Worldware is often multi-purpose, which makes a bigger market. Because most worldware takes the form of tools or resources, rather than being shaped for instruction, it is likely to be more flexible in application than courseware. The same worldware can be used for different purposes by instructors with entirely different instructional approaches to the same course and for many different courses as well.

- Students come in already wanting it, increasing demand and returns to scale. If people in the professional world are using new tools to think in new ways about their problems, and even to tackle new problems, they will soon expect college graduates to already have learned the rudiments of those new ways of thinking. The undergraduates coming into the classroom expect to learn them, too.

- Instructors already know about worldware, too. Because of the software's popularity in the professional world, instructors may already be familiar with it and perhaps even use it in their own research or consulting. Even some students may already have learned to use the worldware earlier in their education, reducing class time needed for training.

- Because worldware lives from a large market, its marketing, technical support, reliability, ease of use and life expectancy are all likely to be superior to the average piece of software crafted by educators for students.

Directed instruction

The most widely used technologies for directed instruction continue to be the lecture and the textbook. In order to make directed instruction richer and more accessible, post-secondary educators are increasingly turning to preproduced video and also to live one-way video with two-way audio. Preproduced video has at least three major advantages as an instructional medium:

- material can be introduced that students in campus-bound settings would typically never see: historical footage, microscopic close-ups, computer graphics, world class lecturers;

- the instruction can be "paused" or reviewed as often as the student likes, and viewed at times most convenient for the student;

- inadvertent errors in presentation can be avoided or edited out.

Live video has the advantage of enabling the instructor to do "just in time teaching", incorporating the day's events and reactions to what students seem to be understanding. A few distance learning programmes and lecture halls now make response keypads available to students;

hundreds of learners answer multiple choice questions posed every few moments by the lecturer, who can then get an instant profile of what the class understands. In some systems, students can also push a button that means "when you have a moment, I have a question".

Two-way video is sometimes used for lectures with an extremely modest feedback capacity, but often this may not be a good use of resources; one-way video with audio feedback augmented with fax may be just as effective and less expensive.

Because of the expense of producing reliable, user friendly courseware, the development of disk-based bodies of courseware has not thus far approached the volume of courseware developed for video and print, but there are some early signs that situation may be changing. Although the most common uses of computer software are for "learning by doing", especially through worldware, faculty do sometimes create course-sized bodies of material that rely partly or wholly on computer software, and some of these packages have been in successful use for many years at many institutions (*e.g.* Morris *et al.*, 1994).

This discussion of directed instruction requires a cautionary note. Ever since the invention of lecturers, auditoriums and textbooks, directed instruction has been the most visible feature of post-secondary education. That visibility and the obvious importance of directed instruction sometimes mislead people into thinking that directed instruction and education as a whole are identical. The exercise in back-to-back drawing illustrates how inefficient directed instruction can be without interpersonal feedback. Nonetheless, there are potent reasons why its importance tends to be over-emphasized:

- Directed instruction can operate economically on a large scale and, as needed, reach distant learners. Once the auditorium is built, it costs no more to lecture to 100 students than to 10. Once the book is written, it costs no more to sell it to 10 000 students than to 100. Once video materials have been created and broadcast, it costs nothing if millions of people watch instead of a few. Since tuition per student is the same for the tenth and the hundredth student, but costs for the 100th student are, in effect, less, directed instruction has the lure of providing a cost-effective way of teaching large numbers of students, even over distance.

- Many tests emphasize memorisation and simple, rote methods of solving problems. Directed instruction may be an adequate way of teaching at this level of learning. Thus programmes that employ only directed instruction, with little learning-by-doing and little person-to-person interaction, may appear satisfactory if measured only with such tests. However, when students are tested for higher order problem solving abilities -- the kinds of skills likely to be even more important for the 21st century than they are today -- programmes relying exclusively on directed instruction may not look as good.

- Instructors and students have been known to indulge in a silent conspiracy to emphasize directed instruction. It can be easier for the students to believe that the learning that matters most is what the instructor tells them. Thus, it can be easier for faculty to accept their position as "sage on the stage", accepting that some students learn more than others in that setting. Although "teaching as telling" has long been discredited in the research literature, it is still widely practiced.

- Early applications of the new technologies also lent themselves to directed instruction: videotapes for training, programmed instruction and computer-based drill and practice, simplistic laboratory simulations. Computer-based drills and tutorials have been shown to be about a third faster and more effective than traditional ways of teaching the same material, but the same limits on broadcast-only instruction apply; the learning is limited to topics where the computer can supply appropriate feedback a high percentage of the time. In those circumstances, software can provide a powerful adjunct to other methods of instruction.

If a wide range of types of learning are to be supported for a wide range of types of students, directed instruction should be complemented by the three other forms of interaction: learning by doing, real-time conversation and time-delayed conversation.

4. What are the missing links?

This report has now summarised a puzzle about teaching and learning. First it described a triple challenge that post-secondary education in many countries must somehow deal with: how to open access to all adult learners, especially the new majority who previously were excluded or marginalised, how to provide all these learners with an education that prepares them for the 21st century and how to do both those things when costs must be tightly controlled.

Second, the report has asserted that a high-quality education has four facets: directed instruction, learning by doing, real-time conversation and time-delayed conversation. The report described technologies capable of supporting more accessible, and richer, forms of each of these four types of interaction. This report will simply assume that the institution, province or country can supply suitable, affordable technologies that support the four facets of interaction, for at least some students and at least some courses of study. But supplying the technologies is the beginning, not the end, of dealing with the triple challenge. Hard-won experience teaches us that merely providing technology does little if anything to improve education. There are links in the middle of the chain of cause and effect that can lead from technology with the *potential* of supporting enriched, extended, affordable education to *actual* improvements that meet the triple challenge.

Hardware and software do not determine how teachers teach, how learners learn or what education costs. The response to the triple challenge is determined by the ways students, educators and policy makers use the opportunities that technology (old or new) provides and by the way they cope with its weaknesses. These are the "missing links" in the model being developed in this report.

How might one judge whether a particular "link" (*i.e.* a teaching practice or way of organising learning) would help institutions respond to the triple challenge? Four criteria are particularly useful in understanding just what sort of restructuring is necessary:

- *Restructuring should result in enhanced involvement in learning and increased time on task.* Most research indicates that, the more time students spend studying and the more of their energy and intelligence drive that study, the more they will learn. Any change in structure or practice should therefore motivate students to study harder while removing barriers to time spent in study.

- It should foster *intimate faculty-student and student-student interaction on a large scale.* These two conflicting requirements must both be met. "Large scale" is likely a requirement in order to manage costs per graduate, since most educational institutions are labour-intensive; thus class size must be larger rather than smaller. Yet research also shows that intimate interaction (instructor-student and student-student) are key to learning for the average student, especially for higher order skills. For example, most faculty lack the information needed to understand accurately what their students actually know and can do; research in physics and other fields reveals that even students who get high marks on tests actually do not understand some of the most basic ideas under study. Good instructors study their students intensively, as groups and as individuals, in order to help them learn. What sorts of practices and structures enable such intimacy on a large scale?

- Restructuring will involve *simple but pervasive improvements in teaching and increased coherence in courses of study.* It is difficult to find research identifying isolated assignments or even isolated courses (*i.e.* classes) that by themselves have an intrinsically valuable impact on the life of the average learner. Ordinarily such an impact requires a number of courses that coherently develop important skills. By the same token, access to education, if only one course, is accessible. Nor are costs brought under control simply because one class is offered in a more cost-effective manner. Continual need for a technology can also justify greater investment in its acquisition and mastery by students, staff and the institution itself. Adults may also be more likely to register for courses if they see a clear, swift pathway to a degree or certificate beyond the initial costs and risks[4]. What sorts of changes in instructional practice and organisational structure are potentially coherent and pervasive enough to enable post-secondary education to respond to the triple challenge?

- Restructuring should increase *equity of access.* One of the several motives that governments and institutions have for meeting the triple challenge is to provide educational services more equitably and broadly. It has been said that the rich get richer, the poor poorer. Institutional response to the triple challenge must consciously be devised in ways that assure equity of access; otherwise the opposite result may occur.

These four criteria direct our attention to three "missing links" -- aspects of a restructured post-secondary course of study -- that would help institutions meet the triple challenge: *1)* a greater emphasis on project-based, collaborative learning, *2)* certain changes in content, and *3)* a division of labour that enables intimate student-student and faculty-student interaction on a large scale.

Project-based, collaborative learning

Many faculty and researchers have pointed to a need to shift some instructional energy away from lectures and simple problems towards more emphasis on students working alone and in teams to frame and work on significant, realistic, open-ended projects: musical compositions, scientific investigations, software development projects, essays, social problem-solving, as appropriate for the student's course of study. One such project is not enough. Whether for learning in the major or as part of a general education, the student needs to work on a sequence of such projects, time after time, and in course after course in order to develop needed skills and insights.

Such projects can help students learn skills of higher order reasoning, gain deeper understanding of basic principles and examine questions of ethics, aesthetics and social implications of professional work. Projects can be used to show how various disciplines can relate to one another. Finally, projects can often engage students' interests and energy more effectively than lectures. Such projects should involve:

- Searching, sifting, analysing, and synthesising large quantities of information.

- Designing and composing, *i.e.* complex and highly personal processes of analysis and synthesis, replete with trial and error, as students work to create a "product". While designing, students must also learn to attend to such subtle issues as the expectations of their intended audience, constraints imposed by a fixed or flexible purpose and an internal sense of aesthetic satisfaction or closure (Balestri, *et al.* 1992).

- Teamwork, both to help students learn skills of working with one another and also to help each of them to learn to become more critically conscious of the difficulties and possibilities of working with people whose backgrounds and personal characteristics are different from their own. In many countries one of the most distinctive changes in the workplace, other than increased use of technology, is the increasingly prevalence of a multi-cultural workforce. Collaborative work is also useful as a means of learning, according to many researchers, even for students who profess not to learn well in groups.

- The exercise of higher order thinking skills such as critical thinking.

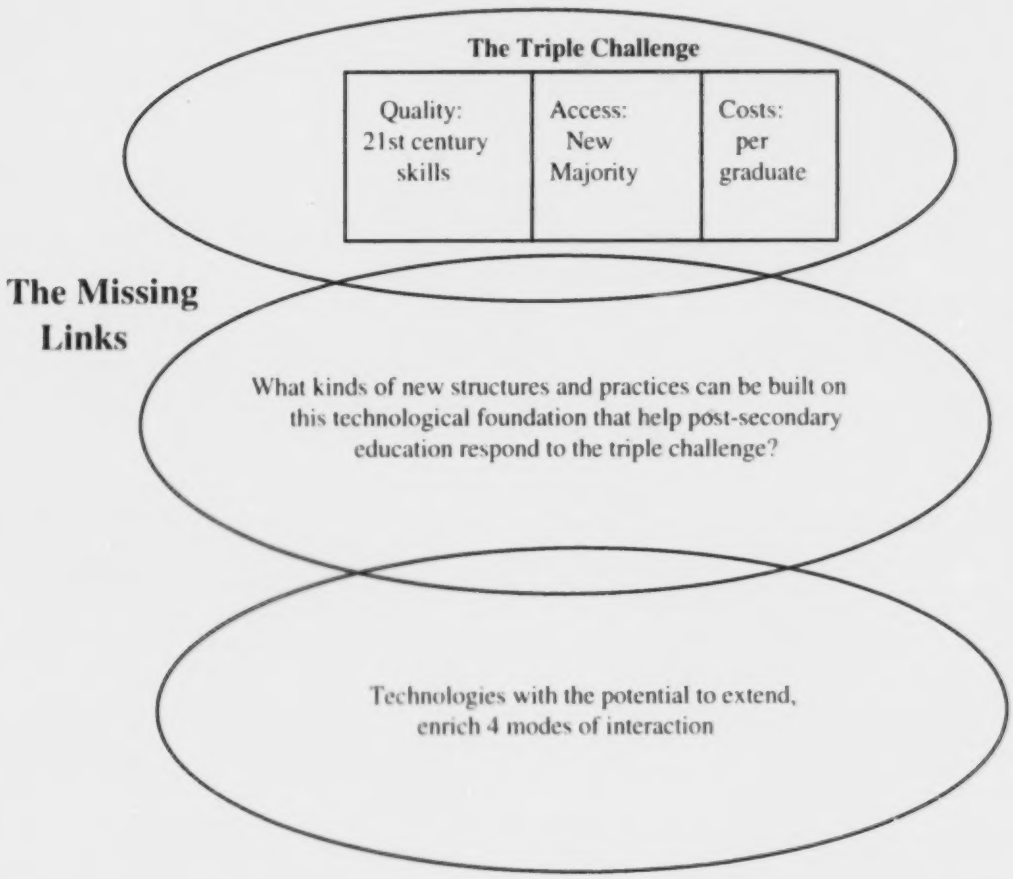
- Learning how to take responsibility for learning in an information-rich, tool-rich environment, *e.g.* deciding what must be learned in order to complete a project.

These skills are not generic; skills of problem-framing or teamwork or learning-how-to-learn manifest themselves differently in different disciplines. Thus each major course of study must consider how to strengthen student learning in these areas. Furthermore, since 21st century skills such as the ability to work in teams are relevant both to one's work and to thoughtful, informed participation in social and political life, collaborative work ought to be part of both the major and general education. The same is true of many other 21st century skills: change is needed in both general education and the major. As already noted, faculty find it more feasible to assign students to work on ambitious projects when students can use worldware and the growing family of networks, including on-line libraries (this is not to imply that such projects are easy, for either the faculty member or the students! Their difficulty can be part of their appeal if the project's content is intrinsically interesting).

Another reason to attend to student-student interaction, including outside class hours, is because of the need to support work on projects. In many institutions without such arrangements, faculty cannot assign students to work on complex projects because, as soon as class-time ends, students scatter to their homes and workplaces. This, in turn, blocks some of the most important facets of learning from ever happening. Students need to be able to converse in real-time and with time-delayed media (making thoughtful collaboration possible even when schedules don't mesh). If appropriate arrangements have been made, students can use the same communications media to consult experts from the world of work as they develop projects; such experts can also play a role in the assessment of the finished projects, giving the whole enterprise further realism and legitimacy in student eyes; by using networks to send the work to experts and to receive their feedback, the process becomes more efficient and more able to include experts who are far away, or whose schedule does

not permit them to review student work during class hours. Such consultations can happen now on a small scale because so few students and faculty seek them; if they are to happen in greater numbers, it will require organised business-education partnerships.

Using the kinds of ideas briefly summarised in the above, large classes can work on such projects. At Rensselaer Polytechnic Institute in the United States, the spring of 1994 saw the first offering of physics to approximately 1 000 students, with only minimal lectures; learning was instead project-based and collaborative. Although the RPI programme was for students who study on campus (some of whom commute to residences some distance away), a similar approach could have been used for students who were more widely scattered, especially if they had access to a network of appropriate computers.


The Triple Challenge
Quality: 21st century skills
Access: New Majority
Costs: per graduate
The Missing Links
What kinds of new structures and practices can be built on this technological foundation that help post-secondary education respond to the triple challenge?
Technologies with the potential to extend, enrich 4 modes of interaction

There are implications for access: project-based collaborative learning can also be a powerful means of extending access to students who have not performed well in traditional instructional settings. In research done at the University of California at Berkeley, for example, Uri Treisman found that disadvantaged students had almost always failed basic science and math courses; by putting them through workshops that challenged them with problems more complex than

standard courses, fostered study in groups, and helped them learn the unspoken wisdom of excellence, his programme produced levels of achievement rivalling those of any other group of students in the university (Treisman, 1985; Watkins, 1989).

Update content

The preceding "missing link" strategy implies that the content of post-secondary courses of study needs to be re-examined: both vocational-professional courses of study and general-liberal arts education. While much of this re-examination lies beyond the scope of a report whose primary focus is on technology and the restructuring of the teaching-learning process, several observations are pertinent:

- In order to master the means of inquiry, of designing and composing and of research, students need to make increasingly sophisticated and varied use of the basic tools and resources of those crafts over a substantial period of time. Worldware as varied as on-line research libraries and databases, statistical packages and computer-aided design software become more rewarding the more experienced and ambitious the student becomes. Thus it is important for courses of study to be coherent (to a degree) not only in their content, but also in their means of study.

- In most countries it is increasingly important for adults, as workers and citizens, to function in a multi-cultural state. Adults who have completed a post-secondary course of study should be especially sophisticated in these regards. Fortunately, video and telecommunications are proving of special value in the study of new languages and cultures: the video provides an "inside" and authentic view of the language-in-action, while telecommunications provides a good medium for the acquisition of a second language and a safe environment for interaction among learners of different cultural backgrounds (*e.g.* Arias and Bellman, 1990).

- The visual dimension of many disciplines is growing richer and more varied. In some fields this is because new computational abilities makes it possible to create visual representations of data and ideas that could only be expressed in text and numbers before. In other fields, easy access to high-quality images as well as to large bodies of text makes interdisciplinary inquiry easier. A single compact disc (CD-ROM) may contain not only many of the key texts needed by a philologist studying a culture, but also many of the images that were previously accessible only to art historians and archaeologists; armed with such discs, even students at an introductory level can ask questions that professionals may never have addressed before and be engaged by the thrill of real research.

Division of labour in teaching and learning

What sort of educational structure can support intimate faculty-student and student-student interaction on a large scale when resources are limited? Successful programmes of this type seem often to share several distinguishing characteristics. Course enrolments are large, perhaps because many adults can reach campus or perhaps because technology enables participation of widely scattered students. At the level of individual courses one often sees:

- Centralisation of at least some of the functions of organising and presenting the course, to insure that least a minimum number of students are served. This may take the form of a multi-institution consortium where faculty from different institutions split the responsibility for organising individual courses that are then offered to all students in the various institutions. In some cases, an open university or other entity may design a course that is then offered to students in one or more countries. Sometimes the presentations in such courses are transmitted via live video; at least as often, the presentational component of the course is developed in advance.

- The students in such a course (who may number in the hundreds or thousands) may be divided into many small study groups. Often members of each group interact on a face-to-face basis, although in some institutions they interact via electronic media. Interaction among groups may also be via electronic media (not excluding the telephone).

- Because these study groups may have significant responsibility, trained mentors or peer tutors may be provided by the institution. Alternatively, the students themselves receive formal training in collaborative learning, especially if the group is then to work without direct supervision.

- Because more responsibility needs to rest on the learners' shoulders for managing their own learning, the curriculum, teaching methods and course resources need to support the continuing development of such skills and motivation. This requires consistently giving students responsibilities for their studies. For example, in one instance in France, students studying in centres off-campus are given a physical problem (for example, where balls fall in a pinball machine) and simulation software, and challenged to develop their own theories of the problem that can be tested through the simulation; the students can communicate with the instructor by telephone (Biolluz *et al.* , 1993).

- Some way of providing common context for these parallel, small group conversations, such as a common videotape or text that everyone studies and then discusses.

- A shared library or other collection of tools, resources and study materials that can be used to help a very diverse group of students pursue similar but not identical courses of study.

Institutionally this sort of large yet intimate education can take a number of forms. Here are a few examples currently in operation:

- The national Open University in the United Kingdom has regional study centres. About 15 per cent of its students (around 17 000 in 1992) are in courses that require use of computers at home to communicate with each other, local facilitators, and course developers through a web of computer conferences and electronic mail. Real-time conversation is done face to face at study centres and by telephone.

- One private institution in the United States (Rochester Institute of Technology) can offer upper division work for a Bachelor's degree to students anywhere in the world. Faculty prerecord lectures on video. Students interact in small groups both in real time (audio- or

audiographic conferencing) and through time delayed conversation (computer conferencing). Tests are administered on-line. Fax is used as necessary to move homework.

- Regional government and national government combine to finance a video network connecting this rural province's colleges and universities to its high schools (Maine, United States). Students go to nearby high schools to watch the college course live and talk back to the instructor by audio connection. The high school also provides computers with modems, fax machines and proctors for examinations. Students use the computers to connect to an on-line library catalogue for the whole province that includes all the books in the college and university libraries as well as the provincial library; students are mailed books on request.

- In a Canadian province (Nova Scotia) with an important linguistic minority, a college has been created to offer courses in the second language. Two-way compressed video and audiographic conferencing link learning centres with the instructor of each course. Those courses with a highly visual component (*e.g.* trade courses) use two-way compressed video while others use audiographics.

Study centres can be important sites for group learning as well as providers of needed equipment, network access and proctoring services. Over 90 community teleservice centres in the Nordic countries provide village communities with access to data processing and telecommunication services, for example. The European Association of Distance Teaching Universities is planning a Europe-wide network of centres.

Which adults should benefit from such centres? If one relies on employers to allow their employees to use workplace equipment and network connections, limited education dollars can be spread further. But will the unemployed and employees of smaller businesses tend to be left out? Will depressed areas suffer? In the United Kingdom, the high price of most open and distance learning programmes was difficult for the unemployed to pay. Recognising this, a one-year pilot project of open learning credits was introduced by the Department of Employment and operated through the Training and Enterprise Councils. Such programmes tend to emphasize skills that governments see as important for "employability."

At some point in the future, the home may furnish adequate technology and network infrastructure, reducing the need for such centres. Of course, the need for places for group meetings, distribution of physical materials and proctoring of examinations will remain. Even that day is far off, however.

In the meantime, political and institutional leaders ought to join in planning ways of sharing the burden of establishing and maintaining study centres which then can offer services from multiple providers. In many cases it may make sense to establish such centres in high schools for use during the evenings and on weekends. In other cases, community or corporate facilities might be used; shopping malls have also been used as the site of study centres.

In designing and equipping study centres, just as much attention should be paid to student disabilities as for students living and studying on a campus. Each disability needs to be considered separately. Equipment and software that can provide special advantages for one group (*e.g.* graphical user interfaces) may pose difficult barriers for another (*e.g.* blind students). Technology has the promise of raising doorways and lessening or eliminating the handicaps that formerly were the

inevitable companions of disabilities, but that will not happen unless special care is paid to each population's particular problems. Highly accessible programmes can be quite helpful for students with special needs. In Japan, for example, the percentage of handicapped learners of the enrolment at University of the Air is ten times that at traditional universities and junior colleges (Mohri, 1993).

Implications for the instructional staff

In addition to the foregoing changes in teaching and learning practices, important changes are needed in patterns of faculty work such as:

- Role transition from "sage on the stage" to "guide on the side". Especially if directed instruction is shared among formerly separate classes, while the proportion of time spent working on projects and in groups increases, the character of teaching for most instructors will shift towards coaching, critique and the design of good projects.

- Greater likelihood that instructors will need to work as part of an instructional team since there may be more than one instructor per team. One study of instructors teaching in both this sort of environment and also in more traditional settings on campus found that instructors usually like this support and missed it when teaching in traditional classrooms. That was especially true for faculty who had begun to depend on technology; in the restructured setting there was almost always someone with them, if only electronically, who could help if there were a technical malfunction or other unexpected event. In contrast, in the traditional classroom, the instructor had to fend for him or herself (Markwood and Johnstone, 1994).

- Increased ability to get feedback on their teaching from students and peers as influenced by uses of technology such as conferencing systems and electronic mail. Self-assessment is also easier when instructors can see videotapes of their teaching and can study transcripts of their e-mail interaction with students.

- Teaching often becomes a more public activity depending on the technology used and the way it is used. Some institutions teach over live cable television systems, for example, in which case the public as well as registered students can watch classroom sessions. The tensions in this issue become more apparent where the degree of "publicness" is under faculty control, as when the lectures are offered over closed-circuit video networks so that students do not automatically have the ability to tape the lectures. Some instructors are reluctant to allow students to have tapes. Several reasons are cited for this reluctance: *a)* their desire to have students attend class and interact with others at their sites and across the network rather than view the tapes later and alone; *b)* they and their institutions might be made to look bad if a single tape were seen by non-students; and *c)* the tape might contain valuable intellectual content over which they would like to maintain control. Other instructors, of course, disagree, arguing that such tapes are valuable for reasons already discussed above in the analysis of directed instruction; some of them also profess to like the idea that others may watch the class and perhaps learn something and even develop an interest in registering for future classes.

5. Strategies for creating the missing links

To summarise, this report has suggested that a restructured post-secondary educational programme will likely feature pervasive emphasis on project-based collaborative learning, updated content and a new division of labour in teaching and learning.

If this sort of restructuring is to occur, several crucial kinds of support are needed, including:

- attention to the ways materials are developed;
- the ways that instructional staff themselves learn;
- the ways the emerging programmes are evaluated.

Supporting materials development and upgrading

Earlier this report urged educators to focus their attention mainly on worldware, despite the fact that worldware, by definition, is not designed for directed instruction. Directed instruction remains necessary, however. What sort of materials are needed? Assuming that education needs to add technology-based materials to a mix that will continue to include print textbooks, what are these technology-based materials most likely to look like? How should they be financed, developed and distributed?

There are barriers to the viability of educational software. In trying to understand what sorts of instructional software deserve development and support, it is important to realise that, whatever else it looks like, such software must be capable of being used for a long time and in many places. Post-secondary courses of study change very slowly (Woodrow Wilson, while president of Princeton University, once likened this task to moving a graveyard). Several decades of experience indicate that long life and wide use are very difficult criteria for software to meet. Many factors tend to prevent video and computer software from achieving that level of use:

- Video use can be limited because video reveals much about the time and place of its production. Frequently those particulars quickly make it seem dated, or foreign, to many users.

- Computer software can be made swiftly obsolete by changes in the computers themselves and in their operating systems. Upgrading software to cope with such changes can sometimes exceed the original costs of development. This is unfortunate because many of the explicit and implicit subsidies that finance the creation of software are not available for its upgrading and porting; for example, grant making agencies are usually more attracted to revolutionary instructional advances than to expensive upgrades of aged materials. Instructors who are pleased and proud to produce innovative version 1.0 may find it considerably less rewarding to create and support version 3.0 when ideas for entirely new software compete for their time; their colleagues, too, while unlikely to consider version 1.0 in promotion and tenure decisions, are even less likely to consider version 3.0 important. On the contrary, instructors often seem to be penalised for spending their time on such software development rather than on "important" activities

such as research in their disciplines. The same is true for highly produced video courseware; updating can easily be as expensive as the original production yet far less glamorous.

- The difficulty of upgrading makes discontinuity more likely, each package different from others, and different from its precursors. Thus, in contrast to worldware, software designed for instructional use is usually unfamiliar initially both to instructors and students. Both groups must be persuaded to become familiar with it and to use it, and this often does not happen. Learning new video or computer software is usually difficult. It is difficult to skim, so even glimpsing its capabilities may take many hours. Learning the nuances is even more difficult, especially since the user interface and instructional philosophy are often different for each different package of software.

- The tiny market for each piece of software, its short life span and the frequency of illegal copying, all discourage private sector investment in post-secondary courseware.

A recent study (Morris *et al.*, 1994) indicates that, despite these formidable barriers there are, in addition to worldware, several families of software that are both of demonstrable educational value and also widely used. These families of software deserve special attention as educators and governments consider how best to respond to the triple challenge. These families of software include:

- *Student editions of worldware*. These packages are developed or at least marketed for instructional use, but bear a strong resemblance to worldware. They may be current or old versions of worldware sold at a student price. They may be developed by faculty with simpler interfaces or adjunct instructional materials. Student editions share many of the advantages of worldware such as the hidden subsidy of research, development and marketing.

- *Niche curricular software*. Developed and marketed for very little money, these packages are also acceptably inexpensive to upgrade. Sometimes they make money, but sometimes their developers keep them alive because of their passion for the subject. Seldom of revolutionary impact, they are more likely to provide modest labour-saving or instructional impact and to fit painlessly into relatively traditional programmes. In sum, this software is useful, but is not likely to be crucial to restructuring post-secondary education.

- *Course-sized bodies of materials* are occasionally viable. Of special interest are materials designed to help institutions increase enrolments by supporting students who seldom come to campus to study. If institutional budgets depend on enrolment, they have sometimes found it worthwhile to share in the development costs of such courseware in exchange for free or low-cost use of the resulting materials; improvements in enrolment help justify the up-front investment in the materials. In courses providing directed instruction with relatively stable content to large enrolments, with faculty playing a tutorial and support role, packages of high-quality course material (print, video, audio, software) can provide a full course of relatively independent study for some students while being used for many other purposes as well. Materials from the British Open University are used in traditional settings elsewhere in the United Kingdom and elsewhere in the world.

– *Extensible software.* This small, but growing, family of software is of special interest for meeting the triple challenge. Extensible software is software that can easily be expanded and upgraded because of its underlying architecture; its structure also tends to make it exceptionally flexible for use in multiple settings and for multiple purposes. "Slice of Life" and "BioSci", for example, are two extensible "student editions" that are both biology videodisks. Both are a decade old and in wider use than ever before. Each one is an archive of slides and short motion segments. Because of this "slide archive" architecture, they can be easily expanded by adding new slides and new motion segments. "Slice" is in its fifth edition, and grows by attracting contributions of slides from its own users.

  - "Perseus" is an extensible CD-ROM and videodisk for the study of classical Greece. Version 1.0 contained the largest collection of images of classical Greece ever assembled; version 2.0, to be published early in 1995, will contain four times as many images. Perseus also contains a huge collection of Greek texts and translations, along with software and on-line references. The power of its underlying architecture is demonstrated by the fact that its original development cost over $2 million, while its port to a Windows operating environment will cost approximately $50 000. It is also relatively inexpensive to design instructional software that gives students well-structured introductions to the larger ideas and resources of software such as Perseus, with "hooks" that guide the student into and out of the database.

  - Another example of extensible software that, like these other examples, can grow by accretion is CUPLE, the Comprehensive Unified Physics Learning Environment. CUPLE includes a multimedia hypertext for the study of physics, laboratory software and software for simulations, all integrated but all capable of growing by accretion. Like Perseus, CUPLE has already grown considerably since its initial development stage and shows promise of growing for many years to come.

  - Both Perseus and CUPLE have attracted interest from developers in other countries who may add materials to their basic structures.

  - Extensible software, if properly designed, may be a key to helping post-secondary education meet the triple challenge; it can support student work on projects but can also, as in the case of CUPLE, include flexible instructional materials.

A huge problem is that no one has enough money to develop all the needed materials. This vacuum has encouraged growth in international co-production. The European Association of Distance Teaching Universities has produced a second-level humanities and social sciences course entitled "What is Europe?", which is being taught in three different languages. The Knowledge Network in Canada engages in similar co-productions. The European Association of Users of Satellites in Training and Education Programmes (EUROSTEP) project, originally funded by the European Space Agency to encourage use of its Olympus satellite, is an effort in international distance learning collaboration, both in production and in distribution of materials.

The Annenberg/CPB Project in the United States is collaborating with producers in Europe, Japan, and Australia to develop several new courses for use in distance learning and campus settings. In a new course on world regional geography, for example, producers from six countries are each filming in a wide range of countries under the guidance of a common plan. The Annenberg/CPB

Project has two other points of interest as a model for how governments, educational consortia and private donors might support the development and distribution of long-lived, widely-used media-based materials.

First, the materials it produces have multiple uses. Ordinarily one assumes that instructional materials are quite specialised. Annenberg/CPB materials exemplify the possibilities of multiple use. Video and other study materials from the Annenberg/CPB Project are used not only for distance learning, but also by millions of students on campuses, tens of millions of informal learners who watch the materials as they are rebroadcast on public television in the United States and learners of all kinds in almost a hundred other countries around the world.

Second, the project exerts considerable control over the materials it develops, has responsibility for their distribution, and retains a share of the resulting royalties. Although materials are sold at a loss, with income that covers immediate expenses but only a fraction of development costs, the staff is nonetheless motivated to expand income by expanding distribution; the income itself is plowed back into marketing and into new projects. Thus the original funding (in this case an original gift of $84 million from philanthropist Walter Annenberg) resulted in revenues sufficient to support all product marketing and support, as well as to fund the development of a new generation of multimedia materials in the years since the original grant ended.

Faculty and staff development on a large scale

No one is more critical to the operation of the educational system than the instructional staff that organises and teaches the programme. Yet few if any countries are handling the problem of helping instructors learn to teach in the new environments, and rethink courses on a national basis. Exceptions include the United Kingdom, which has a Computers in Teaching Initiative with disciplinary centres, each with national responsibility, sited at different universities; each provides training, support materials such as newsletters and consultation in its field. Australia is creating faculty development materials for national use. The Annenberg/CPB Project is funding some projects (some international) whose primary aim is to help educators learn about technologies or to think together nationally about how to restructure particular courses. Many countries have specific projects to spread particular techniques or software. But none have the kind of ambitious programme that is needed to help a substantial part of its instructional corps go through what is almost a career shift.

Such a programme would need two distinct components, one component focused on learning about technologies that have only recently become truly available for post-secondary instruction, the other component devoted to supporting the rethinking courses of study in ways made possible by those technologies.

Learning about emerging technologies

Predictable progress in digital technology enables unpredictable changes in how those technologies might be used. Thus, a single injection of "technology knowledge" is not sufficient. Instructors need to learn continually about the ever-changing possibilities of new technologies. Expertise in using spreadsheets does little to inform instructors about the possibilities of the Internet. In future years, knowledge of the Internet will still be valuable, but will not eliminate the need to help educators learn about expert systems.

Rethinking courses of study: sharing information about technology, technology-based materials and teaching

Even this group of motivated faculty at reasonably well-equipped institutions face daunting problems if they wish to restructure their courses. Imagine a instructor who wants to organise a lower division biology course around student research (literature-based research plus real and simulated experiments). Here are a few of the questions that such instructors today must answer on their own, usually by trial and error:

- There are many useful technology-based resources for such a course and such students (*e.g.* documentary videos, computer simulations, databases on the Internet, packages for data analysis) but what are they, where are they, and what is each one good for?

- What kinds of higher order skills and insights is it feasible to expect these students to develop and what sequences of projects seem successful in developing them? How should assessment of student learning change?

- Week by week during the semester, what's most likely to go wrong? If properly dealt with, do any of these problems represent instructional opportunities?

- Some students are quite adept in using particular pieces of hardware and software, while others are novices. How should the instructor design this course so that these differences in the students' skills are not a distraction?

Further complicating matters is the fact that these answers don't "stand still". Each year brings new technology-based opportunities and fresh understanding of what can be done with last year's opportunities. In the past, instructors could teach more or less as they were taught. Today, with technology powering rapid change in research, in the workplace and in society, it becomes necessary to update teaching far more substantially and frequently.

It is crucial to elicit fresh thinking about how instructors within and among countries might work together in order to update standard courses of study on a continuing basis. Such international efforts to restructure courses where students make extensive use of technology are almost without precedent. In some cases it might involve joint production of materials, but more often the efforts could and should focus on sharing information about existing materials and emerging modes of teaching. The joint effort might develop workshops to help engage a growing number of instructors in the newer ways of teaching the course.

Evaluation and the creation of leverage

Educators and government agencies usually must work "in the dark" as they invest in technology. It is rare, for example, to know with any precision how educators and students are using the technology they already have, and rarer still to have a sense of the benefits and costs of those uses. As a result those who invest in technology and its uses are forced to grope their way forward, as people feel their way through blackened rooms full of obstacles. In such a setting proper evaluation procedures are as vital as flashlights, illuminating at least some of what lies ahead. As yet, however, very few evaluation procedures exist that enable educators and governments to see what is important.

For example, this report has stressed the importance of project-based collaborative learning and increasing student time on task; those are two issues that ought to be monitored by any institution or government that conceives itself to be moving in these directions. There is no commonly accepted procedure for assessing change in these areas, however. Fortunately these issues are likely to be of great concern to educators in many institutions and indeed in many countries. Post-secondary institutions should collaborate, perhaps with governmental sponsorship, in the development and application of such evaluation procedures targeted to monitor progress in the areas highlighted in this report.

Such evaluations would be especially useful in shaping and reshaping national policy and local practice. It would not be surprising, for example, to discover that investments in technology were failing to support increased use of project-based collaborative learning, perhaps because of failure to provide incentives to educators to rethink their courses. But once evaluation spots such a problem, the debate can begin about how to remedy the difficulty and speed progress.

Issues of pricing and trade

In addition to the issues raised in the preceding two sections, there are other, overlapping policy options concerning teaching and learning that ought to be considered by educational and political leaders, including the following.

Internetworking makes it technically possible to distribute academic resources for low marginal costs, often zero cost. In effect, educators and students can sit at computers linked to high speed networks and find the world sitting (seemingly) on their own machines. It is easiest to explore and exploit this world if one does not need to pay a fee each time a new document or service is used. But lack of such fees may discourage development of those very goods and services. Should there be a charge to users or to their institutions? If so, what expenses should the charges cover? Or is it more efficient to make the resources freely available (since the act of billing generates its own costs).

Should such pricing encourage or discourage the import and export of educational goods and services across national boundaries? Internationally, it is becoming common to use technology to import or export graduate programmes across national and provincial boundaries. As with international trade, the benefits of such specialisation of production and common use of products and services can be substantial. As previously mentioned, some countries have already begun coproducing educational materials. Policy-makers need to decide in what ways and in what extent to either encourage or interfere with such "trade".

6. Meeting the triple challenge : a summary

How have the various policies and practice highlighted in this report make it more feasible for institutions to respond to the triple challenge?

Accessibility

Adults, many of them using study centres, would be able to participate in courses of study that feature strong emphasis on project-based collaborative learning along with materials of directed instruction developed for large scale use, supported through real-time and time-delayed communications. Project-based learning is of particular importance because it can engage learners

and foster excellence among students who may not have done well in classes that relied chiefly lectures and reading. Time-delayed exchange by electronic mail and computer conferencing also is of special importance for enhancing access, since many types of students seem to participate more fully in this medium than they are able to do in traditional face-to-face settings.

21st century learning

Project-based collaborative learning and updated content should help students acquire the kinds of higher-order skills of thought and action needed to function in a rapidly changing workplace and a multi-cultural political and social environment.

Costs per graduate

The report has, to this point, said little directly about how rapidly rising costs per graduate might be brought under control. Increasing amounts of money are being spent for information technology so, in one sense at least, technology is part of the economic problem facing post-secondary education. However, the same "missing link" strategies and technology investments that have been recommended for their benefits in enhancing access and enriching quality are also of interest for their implications in controlling costs. The implications for controlling costs per graduate include:

- Major reductions in attrition, due to the excitement and commitment that can be created by project-based, collaborative learning and the social bonds formed through networking; if more students graduate, the costs per graduate can be sharply reduced.

- Increasing average size of classes by enabling higher enrolments in classes that would otherwise be unacceptably tiny, and by making it feasible and effective to offer courses that would otherwise be unacceptably large by creating intimacy on a large scale.

- The possibility of reducing capital and operating costs when students are educated in "virtual space" rather than in brick-and-mortar facilities.

- Sharing resources through networks or inexpensive duplication that each department or institutions might otherwise buy or create separately.

- Reducing costs borne by students. One way to reduce student costs (applicable to working adults) is to reduce the time spent in completing the programme, *e.g.* by reducing time spent in commuting and increasing time spent in studying. If increased engagement and changes in policy make it possible to attain a degree more, the adult may save in one of the most substantial costs of education income that is foregone in order to pursue an education.

- If all these factors enable students to take more classes per year and work more quickly towards a degree, the institution can thereby control costs by using the same physical facilities to educate more students each year.

- The economic motive that compels much of the current and future expenditure on computing, video and telecommunication is clear. The investment is required to meet the first challenge: to offer an education that is seen as up-to-date, and thus to avoid losing

students who would otherwise attend other institutions, perhaps in other countries. To help control this large and essential investment, the report has recommended that educators consider a curriculum that is, relatively, more coherent so that students use the same multi-purpose technologies and technology-based resources repeatedly, gaining mastery over many classes. This strategy should be more cost-effective than strategies that ask faculty to create, and students to employ, different pieces of technology-based material for every assignment and every class.

Continuity and change

Institutions and countries can neither bury themselves in, nor totally forsake, the past. This report has argued that there is an essential continuity not only in how postsecondary education educates its learners, but also in how postsecondary education has changed, and continues to change. The strategies employed by countries and institutions will vary according to circumstance. The underlying trend is universal. The technologies that once helped lead education into cloistered campuses is gradually leading us beyond them. The technologies that once led education from conversation into the Grove of Academy to the lecture hall are now leading learners to a richer and more multi-dimensional relationship with experts and expertise.

NOTES

1. In this report, "graduates refers to adult learners who have completed a coherent course of study. Such a course of study may consist of one or more classes, and may or may not result in the award of a traditional degree. It should, however, foster palpable, valuable learning on the part of its "graduates" which they can exploit in the worlds outside the classroom. It cannot be over-emphasized that the concern of this report is with attaining sufficient, deep learning that the "graduate" can function in new and different ways in personal, cultural, political, and economic life, with which students are privileged to pursue such an education (accessibility), and with much it costs to provide and pursue such an education (costs per "graduate").

2. Adapted from a tale first told by Richard Breitenfeld, President of WHYY, Inc., a public television and radio station in the United States.

3. This typology is explored more fully in Ehrmann (1990 and 1992).

4. "New Pathways to a Degree" was an Annenberg/CPB Project funding programme that supported development of degree programmes for learners studying off-campus, with technologies used to support all four facets of interaction. External funding for the seven projects ceased in 1993, and all seven programmes are still going strong. It appears that one factor in their success was that they did offer a coherent pathway to a degree, with consistent use of their technologies (Markwood and Johnstone, 1994).

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Part II

THE FUTURE OF FACE-TO-FACE AND DISTANCE TEACHING IN POST-SECONDARY EDUCATION

by William L. Renwick
Victoria University of Wellington
New Zealand

INTRODUCTION

This part discusses some possible institutional responses to rapidly changing demands and expectations in the expanding sector of post-secondary education in OECD countries. It focuses on the "delivery actors"-- the universities, polytechnics, colleges, learning agencies, training schemes, and various private sector initiatives -- that provide post-secondary education and training in its many forms. Specifically, it ponders answers to three questions:

- Who will be the delivery actors of post-secondary distance education?
- Is the dual-mode university (face-to-face and distance education) the likely future of all higher education institutions?
- What should then be the interaction between both modes of education, and the consequences on teaching staff, content, and design of materials?

There is a wider context within which answers to these questions are to be considered. The presiding theme of the CERI study is the impact of information and communication technologies on post-secondary education. Accordingly, this report considers the potential of two very different variables to influence institutional responses and policies: distance education and the educational uses of information and communication technologies. Educational usefulness is what links these two variables. While, therefore, there are many references to information and communication technologies in what follows, the touchstone is their present or presumed future usefulness for teaching and learning.

Another point of clarification needs to be made. There are educational technologies as well as information and communication technologies. In respect of the questions to be considered, technologies are by no means to be thought of solely as items of equipment and electronic networks. A technology is any systematic application of knowledge for practical purposes. There are technologies of distance education and of face-to-face teaching. They were developed before the advent of the information and communication technologies that now claim so much attention and they could function effectively without any significant contribution from them. One of the aims of this part is thus to emphasize that there are indeed two variables under discussion, both of which are to be discussed in terms of their present and possible future contribution to effective teaching and learning in post-secondary education.

The second of the three questions, furthermore, highlights the phrases "distance education" and "dual mode" and this foreshadows a discussion from a perspective that many might find surprising, even controversial. But the emphasis placed on distance education in the context of future possibilities merely reflects the way questions of educational policy are being put at the present time. Where, a generation ago, it was the policies and practice of conventional institutions that set the agendas for distance education, the reverse is now beginning to be the case.

The first half of the report gives reasons for that reversal. It is suggested, first, that the best practice of post-secondary teachers, regardless of whether they teach face-to-face or at a distance, is based on some common principles of teaching and learning and, second, that advances in information and communication technology have the potential -- no more than that at present -- to make important contributions to effective learning irrespective of mode of teaching or the circumstances of students. Eight principles of good practice are outlined, showing how these technologies could be used by teachers who see themselves as facilitators of their students' learning. Brief mention is made of some of the opportunities and threats that post-secondary institutions now face as they review their institutional missions in changing circumstances. The three questions are then addressed and, with the aim of focusing further discussion, clarified as to what they imply for policies for the management of teaching and learning in post-secondary institutions.

Four themes run through the report. First, the phrase "distance education" is serving as a proxy for changes in teaching and learning that are more deep-seated and have as much application to the work of face-to-face as to distance teachers. Second, face-to-face and dual-mode institutions must examine and change their internal cultures in important respects if they are to improve the efficiency and effectiveness of what their teachers teach and their students learn. Third, publicly funded institutions in all OECD countries are constrained by the policies of the governments that fund them and are therefore limited in the policy initiatives they can take on their own in response to their changing circumstances. Fourth, the issues of modes of teaching, arrangements that give students more control over their learning, and the use of technology are essentially educational issues. But the infrastructures of educational research, curriculum development, and teacher development in post-secondary education are weak and poorly resourced. Institutional leaders and their teachers, and advisers to governments, are unequally placed when they are called on to make policy decisions that would commit them to greater use of information and communication technology to facilitate self-directed learning by their students.

The mood of the report is thus ambivalent. Developments in information and communication technology hold out great hopes, but for various reasons educationalists are hedging their responses. Experienced distance educators, for their part, are averse to panaceas and most are far from persuaded that information and communication technologies will deliver on their promises for educational purposes. Many fear that a discussion that focuses on information and communication technologies diverts attention from the real issues in their field -- issues which, if they are to be solved, call for a greater application of distance-education technologies which for the most part would be supported by low rather than high forms of information and technology. Hence the question in the title of this part.

1. Changing contexts

From its inception, the OECD has focused attention on a triad of overarching policy issues: how to promote research and development, how to apply innovations to national economic development, and how, through education and training, to increase human capital and direct its efforts to further innovation and economic development. The initial emphasis was on objectives, and the means by which they were to be achieved was left to experts in each sector of activity. Public education systems, for example, were expanded, restructured and developed, and they became more innovative, but the roles of teachers have remained recognisably the same. Increasingly, however, during the last ten years the international debate has been about means as well as ends. Experts are finding that they no longer have the last word on the way professional services ought to be conceived and managed in their own fields of professional expertise.

Three changes of global significance have created this new mind-set. In the first place, Marshall McLuhan's global village is becoming radically different in ways that were scarcely foreseen thirty years ago. Economic as well as social life is being transformed as computers create new forms of interdependence between knowledge and economic activity. Advances in science and technology are increasing the extent to which industrial processes are based on knowledge and driven by it. They are also increasing the speed with which knowledge and skill in workforces become obsolete. Debates about the half-life of knowledge now commonly question whether it is as long as ten years. There are fears that investment in research and development will not bring practical benefit without associated effort in the development of human resources. The implications for continuing education and training within industry are obvious. Enterprises based on information technology, furthermore, are becoming typically smaller and they depend on high levels of skill from all employees. More and more jobs require employees to make decisions and solve problems, and this requires continuous learning. Enterprises thus organised are showing that they can be more flexible than big corporations in their ability to respond to changing market possibilities, but this carries threats as well as opportunities. Employees can no longer look forward to an unbroken career with the same firm and the prospect of a retirement pension. The next strategic move by their firm might make them redundant. More than ever before, since the late 1940s, individual workers are under pressure to take their own initiatives to maintain their employability by adding to their knowledge, expertise and skill. Again, the implications for continuing education and training are becoming obvious.

The second change is towards a much more acute understanding of the essentially global nature of economic competitiveness. Enterprises and nations are asking themselves, as never before, what they must do to achieve and maintain a competitive advantage over their rivals. A new form of social Darwinism has seized the imaginations of economic gurus and national leaders in which nations, with stark consequences for the well-being of their citizens, are contesting for the survival of the best adapted. It calls for strategies for the long haul and, among other things, recognises that forecasts of the changing age-composition of national workforces are of particular importance. With the number of new entrants to the workforce declining, national economies cannot look to them alone for new knowledge and skills, hence the importance of upgrading the qualifications of older workers. The hope for the future is that, taken as a whole, national workforces will be better educated and qualified, they will be able to adapt more readily to changing work requirements, they will be more self-reliant and thus better able to face threats of redundancy or unemployment, and they will have higher living standards. Within the European Union, it is important to note, this tension between global competitiveness and national well-being is tempered by the potential of a very large internal market. But the policies of the European Union are, in essential respects, national policies writ large, with the added benefits associated with regional co-operation.

The third change is ideological. Economic libertarianism has revived its credibility as a guiding light for government policies for economic development. More than that, in many OECD countries it is challenging long-standing assumptions about the way the state should make public services available to its citizens. Education systems in several countries are being deregulated and educational institutions are being cast in the role of competitors in educational market places. Students are being referred to as clients, institutions as competitors for market share. Governments are telling educationalists that education is crucially important and more of it is needed, but not more of the same. Many countries have introduced new funding regimes and forms of accountability whose aim is to steer educational institutions towards greater efficiency (in business terms) in the use of public funds. Regardless, however, of how they are going about it, or of their current levels of participation, all OECD countries are planning increases in their post-secondary sectors. They know they must become, in Torsten Husen's phrase, learning societies, that they must develop systems of mass post-secondary education and training, and that they must spend much more in future than they

have in the past on continuing or recurrent education, second-chance education, and on training within industry[1]. It is at this point that arguments based on economic development and those based on social equity find some common ground. There must be greater access to a wider description of post-secondary courses of education and training by women, disabled people, members of underprivileged minorities, and people living in depressed regions. There must also be greater equality of access between generations. For that to happen, spending priorities on post-secondary school education and training must change, and the expectation is that this will have to be done not by adding significantly to public expenditure but by redirecting money already committed to education and training. The highest levels of expenditure are associated with the full-time education of students in the 18-25 age group, particularly in universities. They are the subject of critical scrutiny in virtually all OECD countries, with the aim of reducing unit costs.

Post-secondary education is of course ceasing to be equated with the 18-25 age group and other full-time students. It is the diversity of post-secondary enrolments that now claims attention. Increasing numbers of students are adults over the age of 25 who may be making a late entry to higher education and who are more likely to be studying part-time than full-time. Their courses may be organised so that they can study off-campus, and many of these students will be enrolled in distance-learning programmes. In Australia, for example, 10 per cent of tertiary enrolments are distance-education students. Many of these -- and this is the case also in Canada and New Zealand -- live in university centres. The flexible nature of distance learning is what makes it possible for them to pursue their studies. And just as advances in information and communication technologies are transforming economies so, too, do they have the potential to transform teaching and learning as we have traditionally known it. It is possible for teachers and students who may be far removed from each other to interact by telephone, teleconference, radio, television and fax. Some can have access to computerised databases at times of their own choice. Developments in computers are giving a new meaning to the phrase "multi-media". It is now possible to assemble texts, sounds, still and moving pictures on the same hard disk, incorporate them in one message which -- cut, edited, copied, pasted and filed -- can be sent to another computer over a telephone line and used interactively by students. No less important, computerised multi-media products are becoming available at costs which, though still high, are rapidly decreasing, so that they can be used in small, portable computers that have more computing power than current personal desk computers. For most teachers and students these innovations are as yet on their educational horizon. But they foreshadow great possibilities for everyone engaged in post-secondary education, whether as teacher or student, and whether working primarily in face-to-face or distance modes.

We are living through a time of changing expectations. Where, previously, institutions of post-secondary education imposed requirements which their students were bound to accept, they must now (for the most part) respond to the differing expectations of more diverse student populations. From acting as if they were the central determinant of their students' lives, institutions are now in varying degrees adapting to the fact that, for many of their students, post-secondary study has to be fitted around the typical adult responsibilities of earning a living and pulling one's weight as spouse, partner or parent in the running of a household, to say nothing of wider community involvement.

Taken together, these changes raise fundamental questions for all institutions engaged in teaching and learning. Within education systems and within universities and colleges there is a growing recognition that teaching and learning are not synonymous. With this goes some acknowledgement that failure to learn is not to be attributed solely to deficiencies in the learner. There is in most OECD countries, too, a strong body of academic opinion that holds that a main objective in post-secondary education should be to enable students to take control of their own learning. Students should be empowered as well as enabled.

In the course of the last generation these issues have been the focus of much academic and public argument and they are still contested issues. The arguments centre on how far post secondary institutions, and universities in particular, should conserve traditional approaches and how far they should acknowledge a changing world and adapt to new circumstances. One thing, however, is scarcely any longer in dispute. The projected costs of systems of mass post-secondary education are enormous and it is generally admitted that they must become more cost-effective and do more with less. This is one reason -- and for governments and their advisers a very important reason -- why distance-education approaches are being given such serious consideration as policy options in increasing numbers of countries in the developing as well as the developed world.

Questions of productivity and quality are at the heart of the matter, and they are being asked in new ways. The question always asked of face-to-face teachers concerns the point at which their effectiveness falls away because they have too many students to cope with. Quality is a function of interaction with a good teacher. But with distance-learning programmes -- and it is the same with other forms of independent study -- the question is how many students can interact effectively with a good learning programme and its associated tutoring arrangements. The expectation is that, with quality held constant, good learning programmes can be more productive than good face-to-face teaching. Note, too, the shift from teacher to student as the active participant.

2. Locating the issues

Two different but increasingly related issues are at the heart of the questions posed in this report. The first is the relative educational merits of distance -- compared with face-to-face methods of teaching and learning. Up until the last few years, it has been an issue of more concern to distance educators who have had to justify what they do in comparison with the traditional work of face-to-face teachers. As an issue it touches deeply-held attitudes about education, knowledge and teaching, particularly in universities. The conventional premise of discussion is that the norms of good teaching are to be found in face-to-face modes and the onus is on distance teachers to demonstrate how far they are able to meet them. The second issue concerns the educational potential of the information and communication technologies that are now available or becoming available for wider use. The second issue is now strongly influencing debate about the first by pointing up the sophisticated flexible, interactive possibilities of distance-learning approaches that harness communication and information technology for educational purposes.

Teachers usually find that they cannot discuss these issues without reference to their deepest feelings about what it is to be a teacher. The key words -- education, instruction, teaching, learning, knowledge and information -- are all highly evocative and they are inescapably normative. Discussion cannot avoid turning on what *ought* to be the case, depending on the value allegiances of those taking part. Where, furthermore, the focus is on distance education, discussion often takes place in contexts of advocacy: there are positions to be defended, consolidated, undermined. Usually, too, such discussions are associated with matters of policy: decisions are to be made about how an education system or an institution should face its future, and choices are to be made as to where resources should be put and for what purposes. Victory for one side of the argument may mean more than defeat for the other side. It may mean the loss of a claim to funding, teaching and other resources.

Much can depend, too, on which word is under discussion and who is interpreting it. Face-to-face teachers can talk about teaching and learning without having to make any reference to distance-learning, to off-campus students, or to such notions as "single" or "dual-mode". This is not

so with discussions of "distance education", which is usually defined in ways that acknowledge the separation of teachers and students in time as well as in space. Off-campus in this discourse is by definition not on campus. The notion of modes of teaching and learning implies comparisons, and comparisons must then be made in relation to criteria. And when criteria are invoked, the proponents of face-to-face teaching and campus life have in the past invariably occupied the educational high-ground. The criteria of good or preferred forms of post-secondary education are usually written in ways that privilege face-to-face teaching on a campus. They also have connotations of advantage and greater benefit. To be enrolled as a student on a campus is to be advantaged. Distance-education approaches have been devised with the aim of reducing the disadvantages of those who are unable to be enrolled on a campus. Whether such disadvantages can be removed entirely is highly disputed, differences of opinion again turning on different value allegiances concerning what "good" or "real" post-secondary education is or ought to be.

Education is usually thought to comprise more than the sum of the subjects or the modules of work that students will complete to standards set by their teachers. One's education has sometimes been characterised as what remains after one has forgotten everything one has been taught. There is, on this view of the matter, a moral, value-laden component that is even more important than instrumental knowledge and skills. Instruction, on the other hand, is often thought of entirely in instrumental terms[2]. The aim is to bring students to the point of satisfactory performance, and the criteria to be met are intrinsic to the discipline or the task. Education, in the belief systems of many university teachers, is what universities impart: instruction is what takes place in technical institutes, trade schools and on-the-job training. Education and instruction belong to subtly different discourses, as do teaching and learning.

In the language of campus life, teaching is synonymous with teachers in their roles of lecturers or tutors who regularly face their students and teach them. Teachers see themselves as educators rather than instructors. They "teach" themselves as well as their subjects and, to the extent that this happens and the results are thought to be morally and/or socially desirable, impart education and not "mere instruction". Learning, on the other hand, is by no means coincident with teaching. Learning is a neutral concept. It refers to anything a person learns from whatever source -- whether as a result of teaching, instruction or self-instruction -- and includes misinformation, erroneous knowledge, dubious attitudes and values, as well as accurate information, attested knowledge and socially approved attitudes and values.

The intent of this report is not to set up either/or contrasts, but differences are to be detected in the preferences of face-to-face and distance teachers, as shown by the different emphases they give to the words "teaching" and "learning" when talking about their work. Different teaching roles give rise to different expectations and to different kinds of performance. Face-to-face teachers understandably equate effective learning with the effectiveness of their own teaching performance. Distance teachers equate it with the quality of the courses that they and their colleagues devise and the availability of support services for their students. The nature of their work forces them to make a distinction between what they want to teach and the ways by which it can be learnt.

This is where the information and communications technologies enter the discussion with their electronic networks and other "spellbinding" practical applications. These technologies break down barriers of distance, and they are becoming interactive. They could transform distance education. With a telephone, a student's lecturer, tutor or instructor can be as near as his or her ear. By being part of a computer network, students can have direct access to data-bases and libraries. With CD-ROM they can have alternative access to similar sources. These innovations are taking the distance out of distance education.

They are also causing the age-old tension between knowledge and information to be discussed in a new context. Knowledge has a basis in information but in conventional discussions of education is often contrasted with it. A person knows something when he/she can transpose information for new, perhaps unique purposes, knows its limitations as well as its usefulness, can make judgements about it and, generally, can place information in an interpretative frame of reference. It is not easy to think about knowledge in isolation from the processes of thought to be used in acquiring it. Again, the direct, personal contact is usually thought to be a necessary condition for acquiring knowledge rather than "mere" information. Socrates still presides in the academy.

Here we are again speaking of an ideal, but the performance of lecturers and tutors often falls short of it. For all those who are outstanding in inducting students into forms of knowledge there are others whose contribution is much less distinguished. The question, then, is whether valued moments of insight and enlightenment must always depend on personal contact with good teachers. The answer is that it may no longer need to.

The best examples of study materials prepared for distance-learning will meet any criterion for the imparting of knowledge. They have come about because the men and women who have devised them have been as much concerned with the way students will most usefully form their understanding of the knowledge which they must somehow make part of themselves as with the content of the knowledge itself. Good distance courses are typically the result of co-operative effort among people who draw on two distinct forms of knowledge: knowledge of the subject and knowledge of the way the content of subjects can in any given circumstances be most usefully organised and presented for students to study by themselves with varying forms of assistance. Inspection of such study programmes shows that Socratic approaches -- where students are led into a subject by means of carefully framed questions which are intended to take them to its heart -- are standard practice. These approaches, it is important to note, have been developed during the last generation for distance education systems that have depended on low technology -- print, post, and local tutors -- rather than telephones, computers, modems and telecommunications. For at least the foreseeable future, the great bulk of distance-learning will continue to use low technology. But regardless of the means they employ, these approaches are properly thought of as technologies of distance-learning.

Such approaches are open to the criticism that, because students must often study in isolation, or because there are unavoidable delays in having assignments returned to them, teaching/learning relations cannot be as immediate and therefore as effective as they should be. Enlightenment can often require a student's urgent question to be answered when it is raised and that usually requires direct personal contact with a teacher or tutor, whether in person or by telephone.

New inventions are, however, making it possible for teachers and students to make immediate connections between information and the complex ideas we call knowledge. Experimental work in the educational applications of hypermedia has the potential to make students active participants in face-to-face teaching as well as in distance modes in ways never before possible. This, they may well be able to do by asking questions through a personal computer while they are attending a lecture or working through a study unit somewhere else -- at the workplace perhaps -- or at home. Computers can provide anonymity that is not possible with the asking of questions in conventional lecture rooms. Comments and questions (especially questions that students are often too embarrassed to ask in class because they think that everyone else knows the answer) could be logged by computer and analysed by the lecturer or the writer of the study unit. One of two things could then be done -- the lecture/study materials could be revised to clarify the point in question or, alternatively, answers could be provided, stored in the computer's memory, and made routinely available through a

programme's "help" function. The hope, in short, is that teacher learning programmes will be refined and improved in the course of time. The lecturer's answers to all the likely and, no doubt, many of the unlikely, questions that can be asked of the knowledge to be imparted will be written into the courseware and therefore into the teaching/learning programme. Students will have access to content that is better organised and presented and they will also be able to tap into well-honed "help" functions. Learning programmes that can be accessed by computer at times and places of a student's choice have the potential to revolutionise access to teaching of the highest quality. And they would pose an important practical question. Once the teaching is distributed in a programme, will it be necessary to continue offering it in face-to-face settings?

Experimental work along these lines raises a fundamental question about the essential nature of what during the last generation has come to be known as distance education. It shifts our attention from the problems of distance to the concept of guided self-study, with implications for face-to-face teaching as well as distance-learning. It opens the possibility of nothing less than a paradigm shift in the way that post-secondary teachers conceive their role as teachers. Deeply ingrained attitudes are being challenged by new technological possibilities. Instead of thinking of part-time, extra-mural and distance students as disadvantaged, teachers must now consider the advantages that information and communication technology could offer *all* students, full-time and face-to-face no less than distance students. Instead of thinking of distance-education modes of teaching as second-best solutions, all teachers must become familiar with the pedagogic principles they express and then ask themselves how far these are or should become part of their personal stock in trade.

The rest of this part proceeds on the assumption that the educational significance of recent innovations in telecommunications lies in the possibilities they open up for guided self-instruction, with implications that are as important for learning on campuses as off them. Be it noted, however, that the emphasis is on "possibilities". The point cannot too often be stressed that teaching/learning courses of the highest quality are the essential requirement, however they are made available to students. Everything depends ultimately on the quality of the thinking that goes into devising courses and courseware, which means the creativity and skill of teachers as facilitators of other peoples' learning. Regardless of how they are presented, courses are only as good as the learning they can offer. If "junk" goes into a programme, only "junk" can come out.

3. The present position

The OECD countries differ considerably in the use they have made so far of distance education and of information and communication technology in post-secondary education. Some can now draw on experience gained during several decades, some have entered the field during the last decade or two, while others still have to do so. Generally speaking, the main focus of policy until quite recently has been on finding ways of increasing access to undergraduate programmes. Developments in most countries in technical and further education and in continuing professional education have been slower. Within countries, too, there have been jurisdictional divisions: university, other forms of post-secondary education, and training within industry are usually handled by different agencies. The record is one of uneven development, and most Member countries are now seeking to bring post-secondary education and training under policies that are more comprehensive and better articulated.

The main impetus towards the use of distance education for university students so far has come from governments acting on the recommendations of planning agencies or advisory bodies. Open universities and dual-mode universities are providing distance education because the

government that funds them has requested, directed or permitted them to do so. It is the same with most, if not all, of the post-secondary institutions that provide distance education in trade, technician and other vocational courses for recognised qualifications. Policy and funding decisions reside in governments or other public agencies, but the position is very different in the field of training within industry. There, the initiatives have come primarily from enterprises acting on their own behalf or from enterprises acting in association with government agencies, often with public subsidy.

At the institutional level, too, there is an interesting range of experience in the different countries. Open universities are the preferred mode in several European countries and in Japan. Other European countries, such as France, Sweden and Norway, have added distance-education programmes to face-to-face universities, making them to some extent dual-mode institutions. In Australia, Canada, New Zealand and the United States, where part-time and off-campus students have traditionally been a significant part of enrolments, various universities and other post-secondary providers have responded with distance education programmes and have become, in varying degrees, dual-mode institutions. Canada has open institutions as well. There, education is a provincial responsibility and different provinces have different policies. Quebec and Alberta have open universities. British Columbia has an open learning agency as well as dual-mode universities.

It is as well to record that, for most if not all OECD countries, a great deal of educational politics lies concealed behind this bland summary. Though they have since justified themselves, the first open universities were set up in the face of scepticism and opposition from the guardians of face-to-face university education (see Perry, 1976). And in countries where dual-mode universities have become the policy response, few of the older established universities have introduced distance-education programmes. Academic life for the vast majority of university teachers has remained centred on the teaching of face-to-face students on campus. Distance education programmes have been seen as peripheral to their real work, part of the university's public service role.

For various reasons, then, distance education is usually thought of in contrast with conventional face-to-face teaching. It is now entrenched in purpose-built, distance-education institutions and is supported by growing numbers of teachers who identify themselves as distance educators and are members of professional organisations dedicated to advancing the cause of distance-learning. Much of the writing about distance education concerns demonstrating that it is what Desmond Keegan (1990) calls "a coherent and distinct field of education endeavour".

Distance-learning is often discussed as if it were synonymous with open learning, but the two phrases are not interchangeable. Open learning summarises a philosophy of education. It advocates the removal of barriers to formal education that have arisen in the organisational, administrative and teaching practices of conventional institutions whose internal cultures have been shaped by face-to-face teaching of full-time students. Distance education is an important way of achieving open education but is not synonymous with it. Flexibility and choice are two main indicators of openness. They show in an institution's admissions policies; in the content of its courses and the way they are organised, in the place or places where they will be made available; in the media of instruction and/or the timing of delivery; in the choices available to students to switch modes or mix them; in the pace at which students are allowed to proceed; in the forms of support available to them and the types of assessment that are used. Open universities have such policies but, to some extent, so do many face-to-face universities. Indeed, post-secondary institutions are best thought of as having a place on a spectrum that ranges all the way from extreme openness to extreme conventionality, with many shades of difference between.

Distance education is best thought of in terms of its processes. Many distance-education programmes are open in the sense that they have accommodating admission policies, but this is not essential to the concept of distance education. It is worth noting here that the recent European Commission report speaks of "open distance-learning". This conveys two important meanings. It acknowledges by implication that distance education is a subset of open education. It is also a reminder that, in the wider context of post-secondary education, most of which is conducted in face-to-face institutions, distance-learning approaches will not, of themselves, be enough to ensure that open education is as open as it must become in the future. The gatekeepers of face-to-face learning in many institutions have so far withheld recognition from qualifications obtained through open universities and other distance modes, and this inhibits the transfer of students from distance- to face-to-face modes and vice versa. Under policies of open distance-education, the mutual recognition of qualifications is a key issue and, with it, the harmonisation of degree and diploma structures.

The impression that distance- and face-to-face modes of learning are separate, parallel educational enterprises has become fairly widespread during the last decades. With this has emerged a tendency to act as if policies that hold promise for one mode are without relevance to the other mode. Two important recent policy documents reflect that tendency. In November 1991 the Commission on Open and Distance Higher Education in the European Community published a comprehensive report (see bibliography) which charts lines of development in what it refers to as open distance-learning in post-secondary education and training in the countries of the European Community. As would be expected, a report on open and distance education deals exhaustively with that subject. But it would seem to be evidence of a state of mind that the only cross references to face-to-face institutions refer to the mutual recognition of degrees and qualifications and to the need to standardize degree formats and requirements. There is no discussion of the potential for teachers in face-to-face institutions of the best practice of teachers whose experience is being gained in distance-learning. The same comment can be made about the report of the Commission of Inquiry on Canadian University Education (Smith, 1991). Distance education gets a useful chapter to itself but again, apart from a reference to the problems distance students have in getting credit transfers to face-to-face universities, there is no discussion of the wider pedagogic significance of the best work in distance teaching and learning.

The CERI study on the Impact of Information and Communication Technologies on Post-Secondary Education thus offers an opportunity to examine possibilities that seem not to have been brought into focus as yet[1]. The question that stands behind this project is not what distance- and face-to-face modes have to offer each other but how both can benefit from the creative educational use of the information and communication technologies that are now available or soon will be. Always, however, in discussions of educational policy there are blind alleys to be avoided. It is essential, therefore, to be clear what the discussion is about before positions are taken on how answers might be administered. This requires us first to unpack the meanings that have come to be associated with "distance" in the phrase "distance education". Distance education is not to be equated with the various means by which courses for guided independent study may be delivered to students. The essence of distance-learning courses is that they have been conceived, devised and produced to support guided self-instruction. The men and women who devise them begin with students and with what they can be expected to bring to a course of study, as well as with bodies of knowledge and any difficulties there may be in "teaching" them "at a distance", and they employ principles of learning to guide students through the courses they develop. Discussions of educational policy should, accordingly, focus on the knowledge and expertise, the forms of organisation, the infrastructures and the funding arrangements that post-secondary institutions must have if they are to produce courses of good quality that students who opt for self-study modes of enrolment can then use effectively. These

are not questions for information and communications technologists to answer; they are educational questions in search of pedagogical answers. Delivery systems are important, but they are secondary considerations.

Within that policy context, new means are now becoming available to give effect to educational objectives. In the 1990s, governments and institutions have been using a wider range of policy instruments than they did a decade and more ago. Among other things, some are making more use of private sector approaches to public responsibilities. For instance, the notion of the strategic alliance is becoming important to post-secondary institutions that are positioning themselves to take advantages of distance-education approaches. To the expert knowledge they already command through their own teachers, they must add knowledge of distance-learning approaches and the expertise required for its effective conduct, and they must also gain access to suitable electronic infrastructures and equipment. One way of doing this is to create consortia of complementary interests. Some examples are given later in this report.

By no means all the initiatives are being taken by education institutions or by other agencies that are usually thought of as public sector agencies. Many private sector companies have developed in-house education and training programmes to the point where they have sophisticated training packages that they are marketing. Public agencies and private sector companies are also putting education and training programmes out to tender. They define their requirements and then use open or selective tendering processes to find what they consider to be the best provider. So far this approach has been used more for training than for educational programmes, but there is no reason in principle why that should remain so.

These approaches are blurring the distinction between private and public sectors in post-secondary education. And because public sector funding agencies are also beginning to use private sector policy instruments, publicly funded institutions are being forced to compete with each other as well as with private providers. Many of the occupational groups in relation to whom these approaches are being used can be well served by distance-learning or self-study approaches, and the implications for the future of distance education are thus very considerable. But their potential application is by no means confined to that sector.

4. Distance education: review and prospect

It is important to remember the pedigree of most distance-education enterprises. They are heirs to the mechanics institutes, circulating libraries, correspondence schools, evening classes, folk high schools, summer schools, extra-mural educational services and many others that have their origins in the 19th century. Their common aim has been to spread enlightenment, knowledge and instruction to men and women who, usually for lack of money and the necessary formal qualifications, would otherwise be prevented from studying for higher educational awards. They serve important social as well as personal objectives, both of which have come to have increasing importance to national governments during the second half of the 20th century. Human resource development has become an economic and thus a political imperative.

Most initiatives in distance education during the last quarter of a century have sought to increase opportunities for undergraduate study. However, much more attention is now being given to the non-university sectors of post-secondary education, as arguments based on equity are reinforced

by considerations of economic efficiency. Both call for greater national investment in the continuing education and training of much larger percentages of the adult population than would have been thought necessary on economic grounds a decade or so ago.

In all OECD countries there are large numbers of men and women who already hold graduate and other professional awards and whose livelihoods require them to keep abreast of advances in knowledge in their field. During the last generation they have been an increasing source of demand on universities and other post-secondary institutions for programmes of postgraduate study and professional continuing education. They will make even greater demands in future. Professionals, who are better able than the underprivileged to pay for their continuing education, are acutely aware of the consequences for their own livelihood of not keeping up to date. Increasingly, too, they are having to interpret their professional expertise in new and changing contexts. There are, for example, questions of accountability and degrees of responsibility in cross-disciplinary projects, environmental impacts to be considered, and various ethical considerations to be aware of in activities where statutory obligations and human rights issues converge. Given, too, the sophisticated nature of the sites where professionals typically work, information and communication technologies are already significant features of their working environment. Engineers, doctors, nurses, accountants, lawyers, teachers and managers and administrators in many countries, to mention only obvious examples, are finding that for some aspects of their professional refreshment or further study after graduation they are participating in electronic classrooms. They do this by remaining on their work site or moving to a nearby site where they can take part in telephone conferences or video conferences or computerised learning programmes.

Professional groups are important for another reason. They involve university teachers in professional schools who would otherwise not expect to become engaged in distance education, they do so at the postgraduate level, and they are very likely to use advanced distance-education technologies. Teachers involved in such programmes can thus find themselves at the cutting edge not only in what they are teaching their fellow professionals in the field, but in the technologies they use to do so. Such developments will make institutions of post-secondary education much more open to potential students in future than they have been in the past.

5. Face-to-face teaching: some problems

Two problems are regularly raised in discussions of teaching and learning in face-to-face institutions of post-secondary education. It is worth noting, however, that both were matters for serious discussion before distance-education approaches offered alternatives and long before the most recent possibilities associated with information and communication technology. The first has to do with the well-documented inefficiencies of lectures as a main mode of undergraduate teaching, the second with the problematic status of teaching as a function of post-secondary institutions, particularly universities. Most university teachers in OECD countries would recognise a point made in the Report of the Commission of Inquiry on Canadian University Education. After noting that in some ways Canada was more innovative than other countries (in the use of co-operative education and distance education, for example), the report stated:

> "Still it is a general feature of universities that, the vast majority of the time, a person is standing in front of a room of students and lecturing to them. In this respect, things have not changed in a century or more. Given the inventive, creative minds that constitute university

faculties, the Commission has to ask why it is that those minds rarely apply themselves to creating changes in their own industry as revolutionary as those they instigate in most other sectors of the economy (Smith, 1991, pp. 47-48)."

As the Report records, there are creative lecturers who do give their minds to making their lectures into effective learning experiences for students. They stimulate interest by posing questions of the material they are expounding, use audio and visual aids to amplify their points, place topics in various contexts to illustrate their significance, draw attention to alternative interpretations and matters that may be in dispute, and suggest lines of inquiry for students to follow up themselves. Nevertheless, the general criticism still stands. Lectures, particularly to large numbers, are essentially one-way transmissions; it is of their nature that students have few opportunities, if any, to ask a question, seek a clarification or make a comment. And, as transmissions, they are often inefficient; explanations are not always coherent or clearly stated; students mishear or misunderstand what they hear, miss some points while they are writing others down, have lapses of concentration and can be distracted by others. These deficiencies can be repaired in tutorials, laboratory sessions, through the use of study guides, and by lecturers who are accessible to students in search of clarification. But the central question remains: for many, perhaps most, of the purposes served by lectures, are there more effective ways of facilitating learning?

On the status of teaching in universities, the recent Canadian Commission recorded comments that also go to the heart of the matter: "The problem is that, when dozens of witnesses spoke of research 'opportunities' and teaching 'loads', they were unconsciously telling us that research and teaching have already been set apart from one another. The question is one of balance". Certainly the words "opportunities" and "loads" signalled very different attitudes to research and teaching as functions of university teachers. Similar comments from review bodies and from influential university leaders could be quoted from most if not all OECD countries. There is a widespread view that excellent teaching ought to be given greater practical recognition in the inner life of universities, as is evidenced by their rewards structures and the signs of prestige and esteem they give their most distinguished members. Also widespread is the view that, for this to happen, the competing claims of research and teaching must be redressed.

In the context of this report, two comments can be made. Particularly in countries where they depend heavily on public funding, universities are unlikely to be able to rework the trade-offs between research and teaching as if they were solely for their own untrammelled decision. They face the twin spectres of more students and of tighter funding regimes. What Japan, the United States, Canada and Norway have achieved -- a quarter or more of each age cohort graduating -- other OECD countries are now setting themselves as targets as they commit themselves to policies of mass post-secondary education. But all countries are experiencing funding limitations. Their governments have a heightened concern for the efficient use of scarce resources and value for money from what cannot avoid being the most expensive sector of national education systems. The quality of teaching and learning, how to improve it, and how to make it available to a larger, more diverse student population is thus an essential part of the policy agenda for face-to-face as well as teaching institutions. One of the questions being asked is how far excellent face-to-face teaching and excellent distance-learning derive from the same pedagogical principles even though they might employ them differently. Another question is how far excellent teaching and learning in both modes can be supported, enhanced and made more effective (in both the educational and economic sense) through the judicious use of information and communication technology.

6. The matter of modes

Many teachers in post-secondary institutions are surprised to discover that they are teaching in what some of their other colleagues refer to as a dual-mode institution. They may have known that their institution was also engaged in the teaching of distance-education programmes but that did not signify any change in the character of the institution itself. Dual-mode is a term which includes distance educators, who are a new breed in what, before their advent, was solely or predominantly a face-to-face teaching institution. As used by distance educators, dual-mode is both a marker and a reminder. It marks them off from distance educators who are working in single-mode distance-education institutions such as open universities, open polytechnics, open-learning agencies and open colleges. It reminds their colleagues that face-to-face teaching and distance teaching ought to be thought of as different modes of teaching and learning, each with its own distinctive requirements. Therefore, for those likely to favour its use, dual-mode serves purposes of advocacy as well as description. During the last generation the advocacy has been necessary and important. It is difficult to think of a country where advocates of open or distance-learning have not encountered resistance. Institutional indifference or inertia has often been stifling.

In countries where it is part of the provision of post-secondary education, therefore, distance education is found in one of two types of institution: an open university, polytechnic or college which enrols only distance students or a dual-mode university, polytechnic or college that teaches face-to-face as well as distance students[4]. In the latter instance, distance students are usually outnumbered, often significantly, by face-to-face students, nor will all faculties, schools or departments be teaching distance students. Both institutional approaches have strengths and weaknesses. The great strength of the open institutions is their ability to concentrate single-mindedly on teaching effectively at a distance. Here the United Kingdom Open University has become an international flagship. It has demonstrated not only that university teaching and learning of the highest quality can be conducted at a distance but that it can be innovative and creative in ways that can be of benefit to face-to-face universities as well[5]. During the last 20 years it has become a model for open universities in many countries.

The model has its limitations, however, as the very high quality of learning materials and supporting services depends on large populations of unmet demand for undergraduate qualifications. Where their admission policies are driven by arguments based on economics of scale, open institutions can find themselves prevented from responding to demands for distant study programmes when numbers are comparatively small. There can be problems, too, in having their awards and degrees accepted by other post-secondary institutions. There have been endless questions of equivalence to be resolved: whether open-university standards and degree structures are comparable with those of face-to-face universities, whether their awards will be recognised as prerequisites for postgraduate study, and whether partially completed degrees will be accepted for cross-crediting by face-to-face universities to which open-university students may wish to transfer.

The high profile of open universities nationally and internationally has tended to obscure the distinctive contribution of dual-mode universities. It would not be too much to say that the impression has gained ground that single-purpose, open universities are the preferred way of offering distance education. But there have been good reasons why dual-mode institutions have been developed in some countries as their preferred approach. Systems and institutions that already have flexible admission policies do not have large backlogs of unmet need that can be quantified and used as an argument for creating new "open" institutions dedicated only to satisfying their educational aspirations. Educationalists, administrators and politicians have not always been persuaded that, in the long run, separate provision is desirable. And within systems and institutions with long traditions

of providing equality of educational opportunity, there have been positive reasons for preferring a dual-mode approach. The dual-mode institutions in Australia, Canada and New Zealand are all heir to that tradition. Their work in distance education grew out of earlier policies for extra-mural study and part-time student status and is directed by the conviction that extension and continuing education programmes for the wider community are part of their institutional mission.

As providers of distance education, dual-mode institutions have their own characteristic advantages and disadvantages. It is clearly an advantage to men and women who have the right to enrol as an extra-mural or part-time student to be able to have access to the study materials, tutoring arrangements and other services associated with distance teaching and learning. It is an advantage when lecturers who teach face-to-face courses are also actively engaged in developing teaching and assessing distance courses in their field. The professional development associated with the preparation and delivery of distance programmes is often referred to as a benefit by such teachers, who say that it has served to improve the quality of their face-to-face teaching. Arrangements for students to transfer their enrolment from one teaching mode and to have credits recognised by other institutions are also easier in some systems.

The main disadvantages lie within the institutions themselves. In many cases, distance-education offerings have grown very rapidly from small beginnings to large enrolments. Policies have developed *ad hoc* and the conditions under which they are administered and taught place those who are heavily engaged in them at what they perceive to be disadvantages. Moreover, however it is organised, distance education makes very different demands on institutional planning, budgeting, facilities, organisation and management. Institutions whose ethos has been shaped by face-to-face teaching have had difficulty in providing adequately for the different requirements of distance-teaching modes.

Nevertheless, the possibilities either of being or becoming dual-mode have recently been claiming much more attention, partly as a result of institutions considering their options as providers of continuing professional education at a time when innovations in telecommunications are making interactive learning at a distance a realistic possibility. It is also a response to projected increases in enrolments in prevailing climates of uncertainty about future funding regimes and an entrepreneurial response to market possibilities, for off-campus offerings in management education which are, in particular, associated again with telecommunications technology.

But there is another and more pervasive reason. In the rapidly changing circumstances of the present time, the advantages that were earlier thought to be with single-mode distance institutions are being challenged. Where, a generation ago, post-secondary education was in most OECD countries thought of as a public good to be provided largely at public expense, it is now being viewed in a very different light. The image today is of private goods that could be supplied from many sources, some of them subsidised by public money, to students who will be expected to bear an increasing portion of the costs themselves. If competitive markets is what the future holds, single-mode distance institutions will not necessarily have a competitive advantage. Their great strength, of course, is the operational knowledge they have amassed as providers of distance education; but it is public knowledge and can be appropriated by others. More to the point, Greville Rumble's article, "The Competitive Vulnerability of Distance Teaching Universities" published in *Open Learning* (June 1992; see also Ian Mugridge's comments in *Open Learning*, November 1992), presents a financial analysis which draws attention to advantages that may lie with dual-mode universities (or with face-to-face universities that may decide to become dual-mode) compared to those of open universities. They already offer a wider range of degrees and qualifications than rival open universities, could diversify at less cost, would not necessarily have to rely on large numbers of enrolments to be viable

as providers of distance programmes, and could offer a wider range of options to potential students. They would be able to shift the emphasis from one mode to the other, depending on changes in the pattern of demand for particular courses. If they were to work together co-operatively as consortia, dual-mode universities could well become very competitive indeed in their distance offerings. Rumble ends his analysis with the provocative suggestion that, in a competitive environment, a distance university's most effective response may well be to become dual-mode by spawning a campus or through a merger with a face-to-face university. As will be mentioned later, however, formal mergers are not the only response available.

7. Modes or mixes?

A difficulty with distinctions is that they become hardened through reiteration. But in a fast-changing world, the conditions that caused the distinction to be made may have changed, raising the question whether it remains valid. Twenty years ago the distinctions between distance- and face-to-face teaching were sharper than they are now. Under typical arrangements, distance teachers and their students were separated in time and space. They kept in touch with each other through printed study guides and comments on assigned work. Efficient postal services were essential to effective distance education. Some distance educators held, as a matter of professional doctrine, that distance-learning materials should be devised so skilfully that students would be able to work through them effectively without further interaction with a teacher. This made a pedagogical virtue of necessity. Where students were cut off from their teachers, their only interaction was indeed with their study materials.

Distance students no longer need be so isolated. Providers of distance education have broadened the basis of their operations. Students signing up for courses can expect to have their study materials supplemented in ways which may include local tutoring, workshops or short periods of concentrated teaching on a campus or at a study centre, teletutorials and regular telephone calls to their tutor, and perhaps the opportunity to take part in teletutorials. The mode is distance, and the students are off campus, but there is regular interaction with tutors or teachers and, for many, there will be some face-to-face teaching as well.

During the last 20 years, too, a great deal of effort has been dedicated to the improvement of teaching on campuses for students in the face-to-face mode. For the most part, the assumption remains that teachers teach through personal contact with their students in lectures, tutorials and seminars, and individually in response to questions raised by students. The aim is to improve the quality of teaching and learning without changing the essential character of face-to-face teaching. Some initiatives, however, have been more radical. The approach to undergraduate medical education pioneered by Western Reserve University, Ohio, in 1948 and taken up in some other medical schools, shifts the focus from teaching to learning. Under "problem-based learning", teachers become an expert resource, devising and organising the courses of study, posing the questions their students are to wrestle with, identifying the texts and resources to be used, acting as guides and facilitators and monitoring and assessing progress. Approaches to learning that foster co-operation among students rather than competition between them have also been pioneered, particularly in the United States and Canada. Assisted as they can be now by computer-assisted learning, face-to-face students can be given greater control over their own learning. Computers, modems, telephones, servers and fibre optics are opening up new possibilities for campus teaching as they are for distance-learning.

These developments have an important bearing on the policy issues we are dealing with here. Processes and approaches that have come to be associated with distance-learning are by no means confined to it, nor should they be. Indeed, the phrase "distance-learning" is coming to be used unambiguously only in its administrative sense, with reference to a category of students, for the purposes of enrolment statistics.

Even as an administrative category, however, distance students are not a distinct set. As institutions become more flexible in the ways they offer study programmes, so do students living in urban centres find that they can mix and match courses. Murdoch University in Western Australia, for example, allows students to choose between face-to-face and distance forms of teaching for the courses they enrol. Some choose one mode or the other, others put together degrees that are a mixture of both. Where, as is happening in many countries, the costs of tuition borne by students is increasing, this fact of choice has important implications for the future. It gives a degree of consumer sovereignty that students have not been allowed to exercise in the past, and it has become a significant influence on enrolment patterns and on the demand for one form of delivery rather than another. It also begins to create a market in which institutions as well as modes of delivery are in competition.

By the turn of the century, advances in information technology could well have the potential to transform teaching/learning relationships for students, whether they are studying on or off campus. The technical possibilities of multi-media and hypermedia are bringing together under one umbrella a number of strands of developments that, until recently, have been pursued separately -- software for computer presentation, media corners, computer-assisted instruction, distance-learning, computer conferencing systems and computer-assisted co-operative learning. Teachers could be "in" computerised teaching programmes and their associated databases and help functions and accessible from wherever a student, a computer, modem and a telephone wire could be linked to wider electronic networks. There have been many false dawns in the past as educationists have overestimated the educational benefits of technological innovation and underestimated the practical impediments to its widespread use. But information technology has the potential to transform learning as we have known it in post-secondary institutions. For that to happen, of course, the facility of the hardware must be matched by the quality of the software to be fed into it. And it is here that educational leaders in post-secondary education are better placed than at any previous time to prescribe the educational purposes to be served. The common feature of the trends we are concerned about here -- whether they arise from distance-learning, resource-based teaching or computer-assisted instruction -- is the emphasis on students as active learners who are studying in their own time and to some extent controlling their own learning. The challenge to educationists is to devise pedagogies of learning that will set the educational parameters within which the information and communication technologies will make their contributions to students' learning.

8. A pedagogy of learning

Some may think it ambiguous to talk about a pedagogy of learning. Pedagogy is usually associated with teachers and lecturers and what they do to facilitate learning by their students. But in its generalised meaning, pedagogy refers as well to instruction, discipline, training and knowledge and to principles applying to them. The discussion that follows shifts the spotlight from teachers teaching to students learning, regarding students as active agents in their own learning and teachers as active facilitators of that learning.

- It should perhaps be emphasized, too, that learning as used here is not to be thought of in any narrow sense. A change in pedagogic emphasis does not imply any change in the aims of post-secondary education. Those aims are variously phrased but they usually require students to:

- broaden and deepen their knowledge of facts, concepts, theories, skills, principles, values and issues;

- develop the generic cognitive skills of thinking, reflection, critical analysis, application, integration, problem-solving;

- develop general strategies for finding answers to questions and solving problems and to develop research skills appropriate to their field(s) of study;

- develop personal qualities of self-esteem and initiative and the ability to take responsibility for their own learning;

- acquire (as appropriate) vocational information, competencies and values; and

- develop personal values which will include ethical standards, awareness and tolerance of other viewpoints, appreciation of their own sense of identity and that of others, appreciation of the values and the value conflicts of their society, and respect for the environment.

In achieving these aims students must develop:

- communication skills: reading, listening, writing, presenting;

- number skills: performing basic operations, tabulating and interpreting data, using statistical operations appropriate to their discipline or field;

- literacy in information technology: knowing how to find out, using databases, computers and other technologies[6].

Some other things can also be taken for granted. Students differ greatly in their personal backgrounds, including how much they have to spend on their further education, previous learning, motivation and the confidence with which they approach new learning tasks. They differ, too, in the institutional resources they can use in the course of their learning: libraries, books and computers, bibliographical networks, laboratories, teachers, other students, relevant life and/or work experiences. And they differ, too, in the learning strategies available to them and the ones they use: lectures, tutorials, learning contracts, syndicates, participant observation, action research, internships, arrangements for co-operative learning, self-directed study, resource-based learning. Whatever the range of possibilities, however, the essential task for students is to make the best use of the resources available to them for their own learning. And increasingly, given the range of resources in post-secondary institutions and the different backgrounds and circumstances of student enrolments, teachers are required to see themselves less as imparters of knowledge and more as sophisticated designers of resources and as facilitators and managers of their students' learning.

A great deal is known about what makes for effective learning, which can be reduced to eight working principles of very wide applicability[7].

Well devised courses are essential to effective learning

The most important decision that many prospective students will make is whether to enrol for a particular course. They will want to know what they can bring to it from their previous learning, the nature of its cognitive and other demands, the level at which they will be pitched and some idea of the kind of performance expected of them. They should be able to try themselves out on exemplar material that introduces them to the academic content of a course and requires them to employ thinking and/or practical skills associated with it.

Courses of study vary greatly but they have one thing in common -- they are intended to encapsulate some body of knowledge or form of experience that students will be expected to deal with satisfactorily through sustained personal application. Most courses take shape in a teacher's mind before they are taught and have a life that is independent of the students who sign up for them. Some emerge from discussion between a lecturer and his/her students. Regardless, however, of such differences, students should know what they should do by way of personal preparation before a course begins.

Course statements should be available well before a course begins. They should provide the aims of a course, an outline of its content and how it will be developed, an annotated reading list, some idea of the issues it will explore, the tasks students will be required to do, the forms of assessment to be used, and the criteria that will be applied to recognise the successful completion of the course. These are essential prerequisites of good teaching and effective learning.

Technological resources can be used to enable students to preview the requirements of a course and pre-test themselves on exercises designed to gauge their responses according to the criteria of satisfactory performance.

Good practice encourages student/teacher contact

Frequent communication between students and teachers is the most important factor in motivating learners and keeping them involved. The active interest of their teachers helps students get through difficult patches and keep on working. By getting to know some of their teachers well, students can reflect on their own values and think about their future plans, and provide comments about their courses of study for lecturers to consider.

Technological resources that increase access to teachers, help them to share useful resources for learning, and provide for joint problem-solving and shared learning, can increase communication between students and teachers. By offering neutral sources of information and guidance, they can assist students who are shy or reluctant to put questions to a teacher or who may be experiencing difficulties with a particular teacher.

Good practice encourages active learning

Learning is not a spectator sport. Students do not learn much by listening to lecturers, memorising set pieces and reproducing answers. They must talk about what they are learning, write about it, relate it to their experience and that of others and apply it to their daily lives. Students also need to know whether they are on the right track and how well they are progressing.

It is a prime function of good teachers to facilitate active learning. But technological resources that give access to data relevant to real problems and which provide, in the form of interactive exercises, different points of view to be reconciled or explained can strengthen active learning.

Good practice encourages co-operation among students

Working with others often increases each person's involvement in learning. Sharing one's own ideas and responding to the ideas of others improves thinking and deepens understanding. Learning can be enhanced by being a team effort rather than a collection of solo performances. The social values to be learnt through collaborative effort cannot be learnt through competitive learning undertaken on one's own.

As time goes on, technological resources such as telephones, e-mail and computer networks can be expected to increase the scope for interaction among learners and for collaborative problem-solving projects.

Good practice gives prompt feedback

Knowing what one does and does not know, what one has mastered and still has to master, can become a focus for further learning. Students must therefore have regular feedback on their performance. At the beginning of a course they need to know how far, if at all, their previous learning relates to the knowledge and skills they are setting out to master. They need frequent opportunities to perform in ways that relate to the objectives of the courses they are studying and to receive suggestions about ways they can improve. There should be regular opportunities for them to reflect on what they have learnt, what they still need to know and how they should go about it in the time available to them.

Technological resources can greatly increase timely feedback if they are programmed with clear criteria for evaluation to enable students to apply those criteria to their own self-evaluation, and if they provide frequent opportunities for them to try themselves out and thus monitor and assess their own progress.

Good practice emphasizes time on task

There is no substitute for the amount of time actually spent on the tasks to be accomplished. Using time effectively is critical for students and teachers alike. This requires teachers to set realistic assignments and for students to work to regular study schedules and learn how to manage that time effectively.

Technological resources can improve the quality of learning by increasing the amount of time students are "on task". They can do this by giving students ready access to the learning resources they must use, facilitating efficient communication between students and their teachers and among each other and prescribing clearly defined cycles of performance and evaluation.

Good practice communicates high expectations

Expecting students to perform well becomes a self-fulfilling prophecy when teachers and institutions hold high expectations for themselves. Students must therefore be able to get clear information about the goals their teachers have for their courses. They should be encouraged to set their own goals, think about the things they most want to learn in the course, and how they can make the best use of the resources available to them while following it. They should be encouraged to do extra reading, writing and independent exploration to reach their learning goals. They should be conscious of the trade-offs between what they want to learn and getting their best grade for each course.

Technological resources which are programmed to challenge students with sophisticated concepts, complex problems and high-level thinking skills in their field of study, which communicate clear, demanding criteria for performance, and which facilitate interactive dialogue, can set high expectations for teachers and students.

Good practice respects diverse talents and ways of learning

There are many roads to learning. People differ in their talents and styles. Brilliant students in a seminar may be "all thumbs" in the laboratory, art studio or at the drafting table. Those rich in hands-on experience may not do so well at theory. All need opportunities to learn in ways that work for them and they also need to be guided into less easy ways.

Technological resources that exemplify different methods of learning through powerful visuals, well-organised print, direct experience, tasks requiring analysis, synthesis and evaluation, with applications to real-life situations, can help students learn in ways they find most effective and broaden their learning repertoire.

These eight principles indicated earlier are presented as principles to be applied wherever organised learning is planned and managed in post-secondary education. They are as relevant to teaching and learning in face-to-face institutions as they are in distance institutions. They contain no surprises for teachers in face-to-face institutions who use problem-based learning approaches, resource-based learning or co-operative learning in their work with students. They are guidelines in relation to which the best distance-learning programmes are developed and delivered. They are the principles advocated wherever post-secondary institutions have teacher or faculty development units and staff with the responsibility of working alongside their colleagues to improve the quality of teaching and learning.

The information and communication technologies that are coming into use have a remarkable and, as yet, largely unrealised potential to apply principles of good practice to post-secondary education. We already know that they can:

- increase the access students have to information;
- increase interaction among students and between students and teachers;
- strengthen student motivation;
- increase students' time on tasks;

- increase the scope for students to initiate and have more control over their own learning;

- increase the scope for inclusion of affective features of learning experiences;

- increase the responsiveness of teachers and institutions to individual differences among students; and

- increase student contribution to the solving of real life problems.

There is, of course, a basic precondition. The technology must be easy to use, readily available where and when required, and affordable. As always, price will limit availability and use.

Wherever teachers and institutions are seeking to apply principles of good practice and are also harnessing the emerging information and communication technologies, they are making fundamental changes to time-honoured practice. Traditional assumptions and conventions about the where, when and how of teaching and learning are becoming obsolete. Differences between face-to-face or campus-based learning and distance-learning begin to break down when discussion focuses on underlying pedagogical principles. The critical factor is not where students are located but whether they can interact with a teacher or a teaching programme. Traditional roles and relationships for students and teachers become substantially modified. There is also a loss of monopoly. Teaching that is available to students is no longer confined to their having personal access to teachers, libraries, laboratories and other students on a teaching campus.

9. Opportunities and threats

Teachers who are committed to improving the quality of their students' learning are encouraged to do so by the opportunities that are opening up through the use of telephones, computers, electronic networks and CD-ROM. But those for whom all this is still outside their personal experience can be full of foreboding. Those, in particular, whose teaching experience has been shaped by the values of face-to-face universities frequently express their concern that a thoroughgoing harnessing of technology will mean the end of university education as they have known it. Higher education, many argue, is not to be equated with formal learning, grade point averages, and the successful completion of degrees, diplomas and other vocational qualifications. Some of the most important values of a university education are implicit in the experience itself -- they depend on the direct personal interaction of teachers and students and the students with each other, and they cannot be packaged or mass-produced through computer software, and accessed by electronic means. What sceptics need to remember, however, is that what may be called the civilising mission of a university education has for five centuries been as much the result of students' encounters with great minds through books, frequently mediated of course by their lecturers, as it has been the result of the direct personal influence of their lecturers and fellow students. Information and communication technologies are now making it possible for great minds and good teachers to become part of the learning experience of students in ways that have never been possible until recently. As with all good teaching, it is the quality of what goes into the programme that is all-important.

And books, which -- along with lecturers and tutors -- are at the heart of traditional face-to-face teaching are also being transformed by the new technologies. It is becoming easier to update a computer disk than it is to publish a new edition of a standard text. Increasingly, in the future, the information to be found in encyclopaedias, atlases, economic and social surveys, yearbooks and other

compendia whose current factual information changes from month to month and year to year, will be stored in computers as well as published in books. For everyone engaged in learning, computers and modems are becoming as important as book shops and library cards.

Nor does the notion of civilised values have the same resonance of even a decade ago. Societies that acknowledge themselves to be culturally diverse are also acknowledging that civilised values can mean different things in different cultural settings. Post-secondary institutions are recognising that, as their student populations become more diverse in age and cultural background, increasing numbers are coming from outside the cultural mainstream, while others have already formed their essential value allegiances before they enrol as students. The recurring emphasis in the practice of teachers in many countries is on the procedural and instrumental values associated with their discipline or field of knowledge. What post-secondary institutions typically now offer are perspectives, interpretations, case studies and studies of critical moments which students will find illuminating and which will train them to make sense of the important aspects of life in what they regard as the real world. Students are inducted into the assumptions, values and working procedures of particular forms of knowledge which they then use as map and navigating instruments to see what kind of sense that form of knowledge makes of the world they live in. Much of the best of this kind of teaching is interdisciplinary and is conducted by teachers working co-operatively. Distance-education approaches have shown themselves to be particularly effective in presenting the various perspectives as well as the expert knowledge that must go into the content of such courses, the study guides to accompany them, and the tutoring they must support.

The question now is whether these approaches should be used much more widely for campus students as well. Instead of seeing themselves primarily as lecturers whose main workplace is a lecture room, lecturers would see themselves as originators of learning materials which, under their guidance, their students would work through, undertaking assignments as required. Lecturers would work closely with colleagues expert in the practical application of principles of good practice to students' learning and with others expert in media, communications technology and publications. They would give fewer lectures, and the lectures would be recorded so that students had a permanent (as well as accurate) record, and so that they themselves could reflect on ways they might be modified or further improved for future use. Because students would have independent access to key texts and to questions posed in study guides, lectures would be interpretative rather than merely convey knowledge and information. For the most part, however, the interpretations and commentaries that once formed the core of their lectures would be included in the learning packages they devised—some as written directions, some as questions to be thought about in relation to selected texts, others as strategically placed oral comments. Computerised multi-media will, in time, make it possible for these and other techniques to be incorporated in disks that students can use in their own time.

Lecturers will have the opportunity, too, to close the gap that frequently exists between statements of course objectives, with their listings of the tasks assigned to students and each student's interpretation of those requirements and their performance in relation to them. Teachers in face-to-face institutions have much to learn from distance teachers who regard it as an essential part of their responsibility to guide their students towards the learning outcomes they have set for them. The best of these study guides, taken in conjunction with the study materials they support, are good examples of principles of good practice in distance modes. Study packages produced by the United Kingdom Open University, for example, not only set standards for other distance education providers but influence the way teachers in face-to-face universities think about presenting their own courses and engaging their students in the intellectual disciplines inherent in their content. Indeed, one of the great merits of distance-education materials is that they are in the public domain in ways that the methods of face-to-face teachers typically are not. Distance-education materials are available for

scrutiny by academic peers, who can learn from them, criticise and adapt them or, using them as a starting point, improve them for their own teaching purposes. And it is that public character, more than perhaps any other feature of distance education, that holds the greatest promise for the pedagogy of learning in institutions of post-secondary education, whatever their mode or modes of teaching.

The public, or potentially public, nature of this information has a wider significance as well. Educational institutions are for various reasons becoming more systematic in the ways they assure the quality of their teaching, learning, research and other functions. The nature of teaching/learning encounters and their cumulative effect on student performance should be at the heart of any procedure for the assurance of quality. Institutions that have teacher (or faculty) development units, perhaps with associated proceedings for regular staff assessment, have an important means for improving the quality of their teaching and learning. Those whose distance-education programmes are supported by instructional design units have another advantage available to them. Given the segmentation of large organisations, the complementary nature of these specialised units is not always appreciated. Both, however, are concerned with the improvement of teaching and learning, and it is a mistake to assume that instructional design units should be confined to distance-learning modes. Particularly in dual-mode institutions, they have much to contribute to the improvement of face-to-face teaching. It is of course a common experience of teachers in dual-mode institutions that their work in the development and teaching of distance courses helps them improve the quality of their face-to-face teaching. There is a strong case to be made for considering teacher development and instructional design as two related aspects of a single unit.

Questions of a different order are inherent in the wider economic context in which all institutions of post-secondary education now find themselves in many OECD countries. One of the main reasons why distance education is attracting so much attention from governments is the hope that through economies of scale, unit costs over the long haul will be lower than for comparable face-to-face courses, and the large expansion of post-secondary education that all countries foresee will be achieved at less cost to taxpayers. An accompanying belief is that post-secondary institutions can be made more competitive in the future than they have been in the past. The personal circumstances of large numbers of that increasingly diverse student population brings both of these policy interests into a powerful conjunction. Students are looking for flexible ways of pursuing their studies, and the increasing user-friendliness of computer technology can provide answers to their needs. In such a competitive environment the policy expectation is that providers of distance education, whether in open or dual-mode institutions, will be better placed to increase their market share of an increasing demand for post-secondary education. And because the market will be competitive in terms of quality for price, all post-secondary institutions will have to give close, continuing attention both to the quality of their courses and supporting services and to the actual costs of producing and maintaining them.

This opens up a great many questions that cannot be taken up here. Four general comments can, however, be made. The first is that, thought of in market terms, post-secondary education is a great many markets, all with special features. It remains an open question as to how far many of these markets can be internationalised to reap the benefits of economies of scale. The prospects are likely to be brighter for courses in mathematics, science, engineering and information technology than for courses in education, law, health, social welfare, agriculture, horticulture and fisheries, and in a great deal of continuing professional education, where national, cultural and regional factors exert strong influences on what is to be taught and how it should be interpreted. No doubt there will be plenty of scope for the educational equivalent of fast-food outlets but it seems equally likely that there will be a

continuing demand for boutique industries as well. To take a current example, it will be interesting to see the results of efforts now being made by various universities to internationalise the teaching of courses in management by distance means.

The second comment is about educational values. Most teachers, at whatever level they teach, have the attitude of craft workers. They expect to have control of their entire operation and to put their personal stamp on it. They look upon the students they teach as "their" students, with whom they are in a personal relationship. These are the things that give them their job satisfaction and shape their self-image as teachers. There are features of distance education as organised in some open universities that teachers who were nurtured in this face-to-face tradition will want to resist. They can be expected to oppose arrangements under which some teachers develop courses they do not teach and others teach courses they have not been involved in developing. But industrial arrangements, and the partitioning of the traditional role of the teacher, are probably unavoidable in large-scale teaching operations driven by the efficiencies that go with economies of scale.

The third comment grows out of the second and has to do with the public roles of post-secondary teachers. As well as teaching their students, they live as members of local and national communities. Their knowledge and expertise and the fruits of their research and publications have impacts which are valued in various ways by people living in these communities. The result is that strong, mutually beneficial bonds develop between post-secondary institutions and their cities and regions. In the language of the marketplace, local institutions can be expected to build up a good deal of brand loyalty. In facing a future in which they are adapting themselves to different student populations in competition with rival and perhaps remote providers, local institutions have advantages they can exploit. Part-time and distance students can be expected to prefer institutions that are close to them so long as their courses are of good quality and their fees reasonably competitive. Local employers and community organisations can be expected to have a similar bias.

This suggests that countervailing influences are at work. In a competitive environment it also suggests that face-to-face institutions confronted with the alternatives of becoming dual-mode or operating on constrained budgets will decide to become dual-mode, at least to some extent. By taking that option, they will place themselves in a position to respond to future market uncertainties by learning how to play open learning institutions at their own game. On Rumble's analysis, they would bring advantages to that contest that open universities might not be able to counteract. They would preserve cherished academic values even while they adapted to the requirements of distance modes because their teachers would remain in control of the courses they developed and taught, regardless of mode. Becoming dual- (or mixed-) mode would require them to come to terms with the telecommunications revolution and, by so doing, they would then be able to respond flexibly to the demands and expectations of their local communities.

Fourthly, there are the apprehensions of post-secondary teachers. In their extreme form these are expressed in nightmare scenarios. Teachers in face-to-face institutions fear the prospect of more students without any compensating increases in operating budgets. Their institution may or may not be prepared to become dual-mode with the aim of providing courses of good quality to a larger enrolment. Government funding policies may not allow them to spend in advance the money they would need to outlay to diversify their teaching activities. Teachers then see themselves caught in a downward spiral: more students leading to larger classes and/or increased lecturing responsibilities. If they are to maintain standards, it will be at the expense of research, scholarship and publication. If the reputation of their university is put at risk, what chance will it have of holding and recruiting the best teachers? Many teachers fear that from a combination of influences over which they personally have little or no control their institutions will be left by the wayside.

Distance teachers, particularly in dual-mode institutions, also have a nightmare scenario. They fear that much of the enthusiasm for educational solutions yoked to sophisticated forms of information and communication technology will turn out to be one of false hopes. For the most part they use relatively low-tech equipment. What they need is firm and consistent institutional policies for conceptualising, developing and managing effective technologies of distance teaching and learning. If there is conservatism in their response, it rests on the proven experience of people and institutions that have already demonstrated what is needed for distance-learning of the highest quality to take place. They are sceptical of claims made on behalf of information and communication technology on grounds of effectiveness, simplicity, reliability and cost. If the enthusiasm for sophisticated information and communication technology is later shown to have been misplaced, they see themselves with the same operating problems but without the benefit of the money, time and energy which, in different circumstances, might have been directed to overcoming them.

10. Speaking to the questions

Who will be the delivery actors of post-secondary distance education?

Among the three questions introduced at the beginning of this report, the answer to the first of these will be strongly influenced, if not determined, by the predisposing decisions of governments. Governments set the conditions within which publicly funded educational agencies develop their institutional policies. Many OECD governments have recently reviewed, or are reviewing, their basic policy stances, with important implications for present or prospective delivery actors in post-secondary distance education. Different emphases are apparent but there are some common themes. More responsibility is being devolved to the institutions themselves to determine their own objectives and to take their own initiatives to achieve them within broad policy guidelines, making, as they see it, the best use of their funds. Funding arrangements are changing and, as well as being more stringent, are being related more to each institution's output of appropriately qualified graduates than to its input of staff, equipment and accommodation. Institutions are being urged to become entrepreneurial and to see it as their role to be responsive to changing demands for programmes of study including, as an important motivating incentive, new and still to be formulated programmes. Students, particularly for graduate and continuing education programmes, are being required to pay all or much of the cost of their courses and this, from the side of consumers, is intended (among other things) to exert a market discipline on the producers of such courses. Some governments are removing barriers to private sector initiatives on post-secondary education and training; some as a matter of policy are encouraging private providers to compete for contracts with public institutions. Long-standing distinctions between public and private sector spheres of activity are being removed. Protected monopolies which public institutions have traditionally taken for granted are being transformed into markets in which public sector institutions will be competing with private sector interests and also -- and perhaps more importantly, with each other.

To the pressures for change coming from governments are to be added those arising from changing enrolment patterns, the new forms of education and training to be provided, and the pervasive influence of new forms of technology. Few post-secondary institutions can remain immune to these pressures and influences, and by no means all of them can be assured of a continuing place in the sun. Some could find themselves merged with, or taken over by, other institutions and, as time goes on, their teaching missions might be broadened or changed altogether.

There has probably never been as much institutional ferment in post-secondary education and training as there is now. This does not so much concern changes of status as, for example, when a polytechnic becomes a university, as of changes in the way institutions are relating to each other under new operating conditions. More important for providers of distance education are the new kinds of relationships that are beginning to form between institutions and other organisations and agencies. These can best be thought of as strategic alliances. They are contractual arrangements that institutions enter into to protect or advance mutually agreed objectives. They are becoming as important for existing as for prospective providers of distance education. All forms of organisation have inherent problems, of course, and it is as well to note as an aside that consortia and strategic alliances are not always assured of success.

The following examples illustrate some of the different sorts of initiatives that are now being taken in various countries:

- The National Technological University (NTU) in the United States is a consortium of 45 graduate engineering schools. From its headquarters at Colorado State University it contracts with particular faculties to offer courses by interactive video and arranges for them to be transmitted in real time to students who will be widely dispersed in North America. Students are enrolled in the school whose programme they are taking, meet its requirements and receive its qualification. The financial arrangements are advantageous to students, the universities in the consortium and to NTU.

- The Open Learning Foundation (OLF) in the United Kingdom is a British response to new opportunities for open learning in advanced academic and technological fields. It is also a response to government policies to increase enrolments and to reduce unit costs. The OLF is positioning itself in an important niche in a national system that can be expected to increase the range and volume of distance courses. It does not enrol students: it draws on the intellectual resources of more than 20 universities to provide academic and professional services to university administrators and teachers who are delivering open- and distance-learning courses within their own programmes of study.

- The Open Learning Agency of Australia (OLAA) was established in 1993 as a radically different way of delivering distance education within the wider context of open learning. The Agency is a consortium headed by Monash University in association with other leading dual-mode Australian universities and the Australian Broadcasting Company, with initial funding from the Commonwealth Government and other contributors. The OLAA will not award its own degrees but will facilitate access for people living anywhere in Australia to the courses and qualifications of the member institutions of the consortium.

- The National Distance Education Centre, based at the Dublin City University and under the auspices of the Ministry of Education, is a consortium which draws on the resources and expertise of universities and other post-secondary institutions. It provides study programmes for people who are unable to attend face-to-face courses or who are seeking a second chance to study at post-secondary level. Its recently launched degree in humanities, for example, was designed and accredited by six universities. The students taking it follow a common programme supported by the Centre and receive their degree from the university in which they are enrolled.

- New Zealand, another small country, has abandoned the use of centrally developed, national solutions. Time-honoured policies based on government regulation have, since 1989, been replaced by policies that require institutions to manage their own affairs in an environment which they are to assume to be competitive. Institutions that had previously not taught at a distance are making exploratory forays (limited by funding stringencies) and are developing working relationships with telecommunications and broadcasting companies. Telecom New Zealand has constructed its Tele-learning Network as a national (and international) electronic infrastructure to be used to link sites for the purposes of interactive learning.

Other initiatives stem from governments that have policies for stimulating entrepreneurial activity through tenders from public sector providers competing with each other and with private enterprises. In many countries this is becoming a standard way of managing and funding the provision of training within industry. Similar initiatives are being taken by large enterprises. They define the educational and training objectives they want to achieve for their workforces, tender for them and award contracts to the institutions or enterprises that best match their requirements of quality and price.

How far private sector enterprises will make inroads into the post-secondary education "industry" is an open question. The potential for "market penetration", particularly in populous countries and in those that share common languages, appears to be considerable. The demand for non-university post-secondary education and training and for continuing professional education will be very great. In most OECD countries these fields are comparatively less well developed than university programmes for undergraduate study. They are the focus of intensifying professional and government interest. One way or another, more public money seems certain to be directed towards them and many countries are using funding mechanisms that encourage private sector enterprises to become involved. Again, telecommunications hold an important key to the future. They make it possible for students to become members of learning networks while remaining in their workplaces. They also make it possible for members of a dispersed teaching faculty to communicate with each other, to collaborate in the development of teaching materials and take part in teaching programmes without being physically present.

In countries where post-secondary education and training is being deregulated there is in principle no reason why projects that lead to the development and delivery of educational "products" should always be initiated by educational institutions. The field is opening for other agencies and companies to mobilise their own strategic alliances which would enable the buying in of their own educational expertise. Publishing and broadcasting companies have done this in the past. With the convergent interests that telecommunications, computer and publishing companies now have in educational markets for self-study courses, an increase in the number of private sector providers of distance education seems more than likely.

The scene is thus being set for a vast increase in institutional networking, with much more scope for entrepreneurial activity in post-secondary education and a blurring of earlier distinctions between public and private sector approaches. Among other things, this raises questions about the regulation of post-secondary education under conditions where there may well be many more delivery agents competing with each other under market conditions. Governments are under increasing pressure to constrain the costs of post-secondary education. But they also have obligations to their citizens to maintain sound academic, professional and vocational standards. Students who feel they are being "ripped off" can also use electronic networks to register their protests or engage in political

action. The idea of a "bill of rights" for distance learners is being discussed in some countries. Is it to be *caveat emptor* or are the providers of post-secondary education to be required to meet and maintain specific standards of performance?

Is the dual-mode university (face-to-face and distance education) the likely future of all higher education institutions?

Only a bold person would answer this question unequivocally for all higher education institutions in all OECD countries. There are at present three broad types of institution: those that teach entirely or almost entirely face-to-face students on campus; those whose enrolments are made up entirely of distance students, though their study programmes may well include some face-to-face teaching; and those that combine face-to-face and distance teaching modes. Different answers are possible for each type of institution.

For the third type, those that are already dual-mode, there is no reason to doubt that they will continue to combine distance- with face-to-face teaching. All the influences discussed in this report confirm the suitability of this kind of institutional response to changing demands and expectations. This is not to say, however, that, simply by existing, dual-mode institutions will be as effective in their work in distance-learning as in face-to-face teaching. Most dual-mode institutions have inherent problems as providers of distance education. Being dual-mode and being *effective* as a dual-mode institution are two different questions. These, and the institutional policies to overcome them, are discussed in the next section.

Institutions of the second type -- single-mode distance universities -- may well find themselves under much less pressure than single-mode face-to-face universities to become dual-mode. The Rumble option is one opening to the future but there are others. They are, let it not be forgotten, institutions that are designed, managed, staffed and funded to advance the cause of distance-learning, and the future demand for this form of higher education will be great and never-ending. Simply by continuing to develop themselves as institutions that provide quality products and broadening as opportunities arise the range of their teaching programmes, institutions may find a winning formula without having to become dual-mode.

Furthermore, the pressure to make more use of information and communication technology may well be stronger than any pressure to become dual-mode. Within distance-teaching institutions it is likely to have a greater influence on future plans and funding priorities than proposals to branch out into face-to-face teaching. This approach would be justified on the grounds that institutions should stick to what they do best (which, in the language of the marketplace, means concentrating on their core business activities). It might well lead to strategic alliances and the formation of consortia, but for different institutional purposes.

The British Columbia Open Learning Agency (BCOLA) provides one illustration. In terms of its teaching programmes it is a single-mode distance-education agency. Its teaching programmes are broadly comprehensive, ranging from second-chance, community and vocational courses to degree programmes. It runs the Knowledge Network, British Columbia's educational television station. The governing board of the OLA includes members of the other universities of British Columbia (which have their own distance programmes) with the aim of mixing and matching the contributions of various institutions, some in the form of distance courses, others face-to-face, to provide learning pathways towards a widening range of post-secondary qualifications. The BCOU is responsible for negotiating the recognition of credits for transfer purposes from community colleges and between

universities for degree purposes. It is also building alliances with industry through its workplace "Training Scheme" which attempts to match OLA expertise and skills with training requirements in workplaces.

The BCOLA is thus part of a post-secondary educational system but confines its teaching to distance modes. In the larger provincial context in which it is working there is no need for it to become dual-mode. Through its governance it is in communication with other post-secondary agencies with the aim of achieving agreed institutional policies and more flexibility and choice for students (see Davis, 1992). It is also a co-operative, not market-driven operation. The working assumption is that efficiency, flexibility and choice -- touchstones of libertarian market philosophy -- will be achieved through institutional co-operation.

Universities of the first type, those that teach largely or solely face-to-face, will need to give the closest attention to a broadening of their mission to include distance education as a carefully conceived, properly managed and funded mode of teaching and learning. For publicly funded universities (and other post-secondary institutions) the policies of their governments will be a determining factor. As with all institutions of higher education, they are being courted with the promises of information and communication technology. That, however, is by no means synonymous with distance education. A university's interest in information and communication technology can be confined to research and experimental work on a relatively small scale in one or two departments. A commitment to distance education as an alternative teaching mode requires a new technology for teaching and learning to be conceived, planned and brought into routine operation. Information and communication technology may well have only a small contribution to make to such a development.

The focus of attention during the last generation has been on undergraduate programmes, but universities that decide to become dual-mode in the future will be responding at least as much to possibilities associated with graduate and continuing professional education. For this reason alone, more face-to-face universities can be expected to become to some extent dual-mode. The policies of prestigious universities -- whether publicly or privately funded -- will exert an important influence. Most stood aloof from distance education when it was associated with disadvantage and with what were surmised to be relaxed admission standards. They serve national and international rather than civil or regional communities. Competition for enrolment is likely to be such that they may not feel under any pressure to diversify their offerings for undergraduates. But, as "market leaders", they may not want to pass up opportunities to develop their graduate programmes, and that will require them not only to use information and communication technologies but to employ sound distance-education technologies as well. And to the extent that developments along such lines would enable them to add to what they may already be able to offer face-to-face students by way of independent, self-directed study, they would have another good reason for embarking on them. It seems reasonable to expect that dual-mode approaches will become more attractive to face-to-face universities in the future than they have ever been in the past.

What should then be the interaction between both modes of education, and the consequences on teaching staff, content and design of course materials?

The future that could be envisaged is one in which, in their day-to-day responsibilities, some students will be studying on, some off, campus and some will use both modes. Teachers will also differ in the nature of their teaching responsibilities: some will teach campus students only, some may well teach off-campus students only and some will teach both. All teachers will make some use of teaching methods that are resource-based and require students to take responsibility for their own

learning, whether working alone or co-operatively. Increasingly, therefore, however they are classified, students will be interacting with learning resources of one kind or another as well as with their teachers or tutors. In that future, the question would cease to be how two modes of education interact but how educational institutions are organised to support teachers for whom a range of back-up resources are essential to their technologies of teaching and learning. That question leads straight into discussion of their inner decision-making processes and the salient features of their institutional culture that shape those decisions.

Educational institutions, like all human organisations, develop distinctive cultures. They develop self-images in relation to which those who control their destiny respond to changing circumstances, encouraging some developments, accepting others, and ignoring or resisting changes they regard as unwelcome or not appropriate for them. Universities are prime examples of institutional distinctiveness in the values they affirm and the inner processes by which they make decisions, advance or protect their interests, and relate to the outside world. But other post-secondary institutions also have distinctive cultures, even though they may be of more recent origin. Some develop aspirations to become universities and this leads them to concentrate on "higher-level" work, sometimes at the expense of their "lower-level" responsibilities. Others, such as community colleges, see it as their mission to develop close working relationships with local industry and their local communities. Whenever educational institutions are confronted with possibilities of change, and are themselves able to influence the outcome, their internal debates will be shaped by their members' perceptions of the kind of institution they belong to.

The distinctive thing about open universities (and also about open polytechnics, open colleges and open-learning agencies) is that they have been created solely to develop programmes of study which they will teach only to distance students. Their planning, management, funding and organisation are all directed to that objective. They bring teachers, media specialists, broadcasters, printers and publishers together in co-operative arrangements that have the character of production processes. They are large and complex, are driven by timetables and they must operate with clockwork efficiency. The distinguishing feature of open universities is to be found in their combination of academic and managerial principles. On the academic side they have pioneered forms of co-operation by directing teams of university teachers to conceive, plan and write courses of study by using interdisciplinary approaches, placing subjects in new intellectual contexts and exploring them from new perspectives. They have given new meaning to peer review through their consultative, moderation and approval processes, and through the public nature of their study materials and supporting publications. On the managerial side they plan and fund their work in cycles which begin with the advance planning and development of course materials which later come on stream as courses of study for which students enrol and are tutored and supported in various ways and are then revised for further use. The ability to plan ahead and spend money on the development of courses that will not enrol students and therefore earn money for the institution before one, two or three years' time is a most important characteristic of open universities and other open-learning institutions.

These academic and managerial characteristics are essential to the efficient conduct of organised programmes of distance-learning. They are much less in evidence as settled features of the internal organisation of dual-mode universities. A few universities -- the University of New England; Deakin and Murdoch in Australia, for example -- were from their beginnings planned as dual-mode institutions (Chick, 1992; Jevons, 1992; Guiton, 1992). Typically however, face-to-face universities have taken on distance-learning functions almost without noticing. Initiatives that were taken out of the limelight and on a small scale have, during the last decade, attracted much more public attention than their proponents might have expected. Administrative arrangements that began as small, informal undertakings by teachers who were personally committed to providing opportunities for off-

campus students may well have persisted long after the pioneering days have passed. Where that is the case it is usually because those who speak for distance education have been less than successful in breaking down institutional resistances to what they are doing. In terms of their inner management, dual-mode institutions are problematic in ways that open universities and face-to-face universities are not.

It is not simply that the distance mode is of quite recent origin in most dual-mode universities. Markedly different views are held within dual-mode universities as to the educational legitimacy of distance-education approaches for university-level courses. Institutions that have developed for generations (in some cases for centuries) in an ethos that values the unique, personal influence of university teachers on full-time students and the educational benefits of campus life, have to come to terms with the very different approaches to teaching and learning signified by distance-education approaches. The underlying issue during the educational debates of the last quarter of a century was whether distance education, however defined, could do as good a job as face-to-face teaching. The assumption was that face-to-face teaching was the norm in relation to which distance education had to prove itself. The educational and social values subsumed in that norm were such that distance education could scarcely ever be expected to achieve it. And it was usually taken for granted that, simply by prescribing the norm, proponents of face-to-face teaching were themselves achieving it. Those responsible for distance education programmes frequently felt that they were alien to its predominant cultural values. In the unending competition for staff, equipment and running expenses they have usually been among the poor relations.

One consequence of this internal debate has been to generate a discourse of advocacy that has emphasized differences between distance- and face-to-face modes. And the advocacy has been necessary because, typically, the processes of internal decision-making and management in dual-mode universities do not give proper weight to the requirements of its distance mode. But the central argument of this report is that times are changing. Earlier, sharper distinctions between face-to-face and distance modes are becoming blurred. New technologies are opening up important possibilities that university teachers should embrace, regardless of the circumstances of their students or the previous manner of their teaching. The uncertainties of competitive environments are such that all who draw their pay from an institution have a personal stake in its successful adaptation to whatever the future holds.

In the world that is emerging in the OECD countries, it is becoming less open to proponents of face-to-face university education to determine the norms and conditions under which teaching and learning will be carried out. Students and potential students have a greater range of choice as to where and how they will pursue their studies in post-secondary education. Developments in communication technologies are making it possible to create learning networks that combine varying amounts of face-to-face teaching, self-directed study and tutorial assistance. The student populations who are experiencing this growing diversity in the way that teaching and learning is becoming available are themselves the first generation of the telecommunication age. They have grown up with computers and multi-media learning packages in ways that, so far, many of their teachers in post-secondary institutions have not. The challenge to a face-to-face university is to transform its internal culture. The decision to become more open and flexible and to found its teaching on a sound pedagogy of learning has revolutionary possibilities.

In terms of openings to the future, the issue then becomes how to shape a discourse that teachers in both modes will feel they are part of and to whose further development they can all feel they have significant contributions to make. That should be done by concentrating on elements from each mode that have pedagogical value in an era in which effective teaching and learning could be

greatly enhanced by information and communication technologies. To put the matter that way is to change the terms of the debate. The question is no longer whether face-to-face universities should become dual-mode but how they can become more open and flexible in their teaching and base it on principles of good practice. If they are to answer that question, universities must correct the biases of their internal culture, and, to do that, they must review and (probably) refashion the structures and processes that influence their effectiveness as learning institutions. Specifically, this calls for:

- an institutional commitment to excellence of teaching for all its students through whatever pedagogic strategies it decides as matters of policy to use to meet their circumstances and learning requirements, having regard to the attested contribution of information and communication technologies;

- effective internal decision-making procedures for the setting of academic standards, goals and priorities, the planning and funding of the teaching/learning implications of academic reviews and developments, and for the personal accountability of teachers towards their students;

- a continuing focus in the institution's day-to-day life on the requirements of effective teaching and learning through the work of teacher (or faculty) development units and other arrangements such as programmes of research and development that actively involve the teachers;

- the effective planning, management and evaluation of arrangements for resource-based teaching and guided independent study, whether for on-campus or off-campus students, having particular regard to the known requirements of such systems for up-front capital expenditure and efficient servicing networks;

- arrangements for the induction of staff into the nature of their teaching responsibilities and programmes of staff development aimed at assisting all teachers to improve their performance as facilitators of student learning; policies for moderating teaching loads according to the differing demands of their teaching responsibilities, including responsibilities to develop and revise study packages for resource-based learning and guided independent study; and policies for recognising and rewarding excellent teaching;

- open, flexible policies for the enrolment of students, the recognition of prior learning and the pace at which students may pursue and complete courses and study programmes; accommodating regulations for students who want to transfer from on-campus to off-campus or combine a mixture of both; and effective arrangements with other institutions for them to transfer enrolment and credit.

It is a prime responsibility of institutional leadership to ensure that all these factors are properly attended to in the interests of effective teaching/learning, however organised.

Important as these factors are, however, they are not by themselves enough to change the internal culture of universities and other post-secondary institutions. Most of them depend on public funding, and the nature of that funding almost always precludes investment in programmes of study that have long planning horizons and make intensive use of academic and related professional inputs in their planning and development stages. Indeed, the experience in many countries is that allocations of finance beyond the current operating year are becoming more and more difficult to make. But it is not possible to develop programmes of distance-learning or convert face-to-face courses to distance

modes or to resource-based learning approaches without the ability both to plan ahead and to commit expenditure in advance. Many public institutions are locked into traditional ways of teaching by the rigidities of funding schemes imposed by governments. New approaches to institutional funding will be required in a future in which all institutions must be more attentive to the differing expectations of students and to new ways of satisfying them.

11. Pushes and pulls

Wherever there are pressures for educational institutions to change the nature of their work it is important to have a clear view of those pressures and of the capacity of the institutions to respond constructively to them. At the present time, it would seem that open institutions on the one hand, and face-to-face and dual-mode institutions on the other, are very differently placed. The outside influences that are pushing open institutions to be open and flexible in their responses to new possibilities are matched by internal cultures that are pulling them in the same direction. With, no doubt, notable exceptions, the same synergy is not a strong feature of face-to-face and dual-mode institutions. It is not simply that their advocates of self-directed learning are perceived to be minority interests in larger academic communities. For the most part, a proper basis for constructive dialogue is lacking between an institution's various teachers, whose knowledge is the reason for its being, and the respective emissaries of distance; resource-based, or self-directed learning and of information and communication technologies.

There are, in fact, two dialogues that have to go on at the same time. There is the dialogue between those who are expert in their subject and those who are expert in translating it from oral teaching modes to courses of study in which a teacher's knowledge and teaching skill is encapsulated in learning materials. In that respect, of course, dual-mode institutions are better placed than face-to-face institutions, few if any of whose teachers may have the latter expertise. Then there is the dialogue between teachers and the emissaries of information and communication technologies. Where that dialogue is joined, most teachers find themselves on the defensive and often at a loss. More is involved than mutual incomprehension. Teaching, as noted earlier, remains essentially a craft occupation. It is also a cottage industry. The business of teaching and learning has not so far benefited from more than a tiny fraction of the funding for research and development that stands behind the current state of the art in information and communication technology. When, therefore, teachers are asked how they could use new forms of technology they frequently have little more than personal experience, supplemented by that of their colleagues, to guide them. Instead of being able to prescribe requirements based on research and development in the teaching of their subject -- requirements that would specify the development of suitable forms of software -- they are typically confronted with new items of equipment that have been designed primarily for other purposes. Instead of being pulled towards technology that will provide answers to their pedagogical questions, they are being pushed towards items of equipment that are being promoted as the latest "hot" product in some company's marketing strategy.

One of the unsatisfactory features of the situation that has developed over many years is the modish nature of experimentation in the educational uses of communications media. Beginning with radio in the 1930s and television in the 1950s, various technological innovations have been heralded as educational panaceas. Audio graphics, videoconferencing, computer graphics and multimedia linked by servers to hypermedia are the contemporary offerings. Not until use of each new technology has passed beyond the experimental stage have its educational limitations become evident. This is a consequence of starting from the wrong end, looking for educational applications for new technology instead of first being clear of the educational objectives for which suitably prescribed

equipment and supporting infrastructures could then be developed and tried out. It is reasonable to suppose that the weaknesses as well as the strengths of particular technologies and mixes of technology would be shown up during such processes of research and development. It is not surprising either that some of the best courseware so far developed for educational purposes is the work of computer companies. They have the commercial impetus to commit themselves to research and development in courseware as well as hardware products with which they expect to increase their market share.

Nor do all educational users have the same policy interests. Audio- and videoconferencing have much to offer institutions that are looking for ways of coping with course enrolments which are too large for lecture rooms, that are organising teaching programmes where face-to-face students are on more than one site and are reaching out to off-campus students. So long, however, as such arrangements are confined to real-time presentations, they are limited in the amount of interaction they can allow and they are accessible only while they are happening[8]. They do something, but not a great deal, to achieve the policy objectives of education systems where the demand is for vast increases in the amount, type and variety of education and training programmes of attested quality that students and trainees can study at times and places of their choice, in relation to which they can be active learners and over which they can have some control of their own learning. The guess is that the future for education systems lies with technologies that store sophisticated teaching/learning programmes and enable students to interact directly with them but in their own time.

But guesses are not good enough in policy-making. They should be turned into hypotheses to be explored and tested against the educational criteria they are intended to satisfy. Excellent teaching and effective learning, however they are achieved, are both the beginning and the end of the enterprise. The overriding aim of educational policy is to maximise this. Computers and telecommunications are already contributing significantly to that end and they have the potential to do a great deal more. The question is how to match technological means to educational ends, to produce results that are beneficial to learners as well as to investors in telecommunications and computer stocks. It is the message that matters, not the medium.

NOTES

1. See for example the report of the DEET/OECD Conference, "Elite to Mass Education", held in Sydney, Australia, in June 1993.

2. For Americans and Canadians, the word "instruction" may well have other resonances that blur the distinction made. Teaching positions below the level of assistant professor are often known as instructor: instruction is what they give, and their instruction can be as wide and deep as knowledge itself. In that semantic field, distinctions between knowledge and instruction are not as sharp as the one drawn here. By extension, instructional design, an essential element in distance education technologies, has wide connotations.

3. Other straws are in the wind. In Australia, for example, the National Distance Education Conference has recently changed its mandate, membership and name so that it can give greater attention to the application of distance- and open-learning technologies to all Australian post-secondary students, including those on campus. The new name is the National Conference on Open and Distance Education (*Campus Courier*, 8-14 July 1993, p. 2).

4. The notion of duality can be ambiguous. Here it implies some degree of common experience among members of teaching departments with responsibilities for face-to-face and distance students in the same or allied courses of study.

5. "Review of the Open University" conducted by the Department of Education and Science and the Open University at Milton Keynes, 1991, pp. 51-54.

6. Personal communication from Dr. Cedric Hall, Director, Teaching and Development Centre, Victoria University of Wellington, New Zealand.

7. Except for the first, the principles discussed here were developed by Arthur W. Chickering and Zelda F. Gamson, published by the Johnson Foundation as *Principles for Good Practice in Undergraduate Education* and widely used in the United States, Canada and the United Kingdom. With assistance from Arthur Chickering and Janet Jenkins, they have been adapted to include possibilities now becoming available through information and communication technology. The principles are set out in three short booklets, each in the form of an inventory with questions and a rating scale for personal responses. Each booklet is aimed at a different readership: the institution as a whole, the teaching faculty and the students. The principles are the same but the detailed questions differ for each type of respondent.

8. Audio and video tapes can, of course, be made and distributed both as a record and for "secondary" users.

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Part III

STUDENT OWNED COMPUTING
THE ISSUES FOR HIGHER EDUCATION MANAGEMENT

by Gordon Bull
University of Brighton
United Kingdom

INTRODUCTION

This report was produced from a workshop held on September 1992 at the University of Brighton. Although the work was commissioned by the IMHE Programme of the OECD, the workshop itself was generously supported by three UK organisations. The Council for National Academic Awards (CNAA), under its Development Programme, was interested in the outcome in support of its concern for widening participation. The Training, Enterprise and Education Directorate of the Department of Employment (TEED) was interested in the outcome in support of its concern for the use of technology. The University of Brighton who organised and hosted the workshop was interested in the outcome since it is actively responding to the increased ownership of IT in the academic community.

Student-owned computing was chosen as the topic for the workshop/report since it was apparent that the number of students studying at HEIs who owned their own computer was rising. Not only that, but as the cost of personal computing continues to fall, all the predictions are that more and more students will purchase their own computers. It is expected that this trend will occur across all disciplines although the rate of take-up will vary.

There are many problems associated with students owning their own computers if they are to use them productively in their studies other than as stand-alone word processing units. Some of the Higher Education Institutions (HEIs) visited as part of the initial study were already responding in a positive way to the potential of student ownership and had established structures and support systems to ensure the maximum benefits for both the students and the university. From the initial findings and from subsequent discussions a number of broad topics were identified as central to the whole debate. These centred around three main issues which might be summarised as academic decisions relating to course design and delivery, resources and how these were provided and controlled, and social aspects to do with culture changes in an institution. This grouping both structured the way the workshop was organised and as a result, the way this paper has been organised.

As the discussions in the workshop developed it became clear that the main issues were:

- the real cost of ownership for the student;
- the cost to the institution of providing an appropriate infrastructure;
- the need for standards;
- the need to base an IT infrastructure on the institutional goals and missions;
- the central role of the network and the services on the network;
- the need to provide support to enable users to gain maximum benefit from the services provided;

- the importance of staff acceptance;

- difficulties associated with changing the culture of an institution;

- the need to recognise the impact of information technology (IT) on social as well as academic outcomes;

These points are all explored in some depth within the paper.

The first section of the report addresses academic issues, although since the inter-relationships between academic, resource and social issues are not clear cut, this section also raises issues in other areas. The core of Section 1 is a table. This table identifies the major IT potential for HE and the educational or academic goals to be attained by realising this potential. Subsequent columns identify the impact of realising the potentials on course design, the institution as a whole, the faculty staff, and the students. In addition the technological infrastructure required is identified (which can be related to a similar discussion in the resource section).

The second section addresses the issues associated with resourcing and attempts to identify the main cost drivers both for the student and the institution. An attempt is made to quantify these costs although in an ever changing market these can only be seen as guides. In identifying the costs to the institution, various services which an institution might provide its user population are identified. The need for standards is identified.

The third section of the paper identifies the important groups of individuals within an HEI and for each group or groups (where they lead to similar outcomes) discusses the properties of the group, the effects of student ownership on the group, and makes recommendations as to what actions could be taken in order to address a range of social and human problems that could arise.

The final section draws conclusions and indicates the kinds of actions higher education (HE) management need to consider in establishing and maintaining an IT infrastructure which is supportive of the institution's goals and mission.

The electronic campus is covered in detail in the Annex.

1. Academic issues

Explanation

In answering the question, "What are the academic aspects of student owned computing?" it is assumed that all students at an institution will have or have personal access to a computer.

Students, teaching staff and support staff will need and want their own machines to avail themselves of the many IT services. As technology continues to become cheaper and better, the price of "end-user devices" will no longer be a barrier for individuals, who will look to their institution to supply an enabling infrastructure. Institutions that do so poorly may be less competitive. The heart of an infrastructure is the network, beginning with the physical medium and through to network service applications, although more than just these technical services must be provided. Network service applications are arrayed along a continuum from content free to content laden. E-mail, a prime

example of a productivity tool, is content-free, whilst tools to access scholarly databases, perhaps a network client that accesses the Oxford English Dictionary, are content-laden. Support necessary to use the infrastructure advantageously must also be provided, including consulting, training for basic tool use and tool use within the individual's context. For example, teaching a mathematical student to create complex formulas in a word-processor, or a language student to efficiently conduct searches of foreign language databases.

Questions that influenced our thinking

Perhaps the largest determinant of student IT use are the demands for IT from staff and the example they set students. Many staff have not changed the way they teach for many years. It would be presumptuous to think that IT will now "rescue" staff from their "old-fashioned" ways, although we believe that IT increasingly has much to offer the process of teaching and learning. The main questions considered were:

- How might staff be encouraged to consider uses of IT, from simple uses to the redesign of courses and curricula?
- Must the IT environment become extremely easy, powerful, and inexpensive before staff will begin to exploit it?
- Might staff harbour obvious and not-so-obvious fears regarding the use of IT and how it might affect them professionally?
- With or without staff acceptance, will a large number of students eventually acquire computers, and will institutions establish an IT infrastructure, so that "staff acceptance" will become debatable?

Explanation of the table headings

Potentials

The first column of the table tries to identify major IT potentials for higher education including the use of the computer to teach specific subject matter (Computer Aided Learning: CAL) and the educational or academic goal to be attained by realising this potential. There is no evaluation or discussion as to whether these goals will necessarily be reached simply by employing a particular IT potential. For example, for CAL the stated goal is greater teaching and learning quality and efficiency, although we do not claim that CAL use will always be associated with greater teaching and learning quality and efficiency.

IMPACT ON COURSE DESIGN							
IT Potentials	Educational Goals	Educational Strategies	Modes of Delivery	Institutional Impact	Impact Staff	Impact Student	Needed infrastructure
a) Provide a new educational environment to better prepare students for an ever-changing society	Teach meta-skills in addition to knowledge transfer. Buzzwords: critical thinking/ permanent learning/ life-long learners, creativity, problem solving capabilities	More discovery oriented, problem solving	Computing/ networking as adjunct to traditional teaching methods, e g networked distributed multimedia	Consideration of IT services in the design of an institution's curriculum. To the degree that IT may serve as a labour-saving method, staff may devote more time to teaching, to other activities, and, an institution may require fewer staff	Staff need to become increasingly cognisant of IT as courses and the curriculum are updated. To the degree that IT may serve as a labour-saving method, staff may devote more time to their students, engage greater numbers of students at a time, or may be able to devote more time to research. The rewards and incentives for the use of IT may become more favourable	Students further encouraged to become more active and responsible, but with concomitant rewards	High bandwidth network 1 student/1 station
b) Increase teaching and learning quality and efficiency *1)* Computer Aided Learning (CAL) *2)* Computer exercises	Not necessarily changed	Adjustable by teacher	Interactive media	Constantly upgrading infrastructure. Provide centralised support for courseware production and delivery. Co-ordinate decision making on what modules are to be "computerised". Provide incentives to staff to invest time	Less lectures/ more focus on individual student, teacher becomes "coach"/ be domain-expert in development team/ exercises require larger item banks	Less massive courses/social consequences less commuting	Increase computer to student ratio

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IMPACT ON COURSE DESIGN							
IT Potentials	Educational Goals	Educational Strategies	Modes of Delivery	Institutional Impact	Impact Staff	Impact Student	Needed infrastructure
c) Increase teaching and learning quality and efficiency *3)* Assignments given electronically, *e.g.* via e-mail, which may ask students to use network tools	No effect on educational goals	Guided discovery	E-mail instead of paper	Constantly upgrading infrastructure Simple e-mail system with good management	More discursive teaching	More active learners become micro-researchers	Necessary: each student passworded mailbox. Networked home machine is preferable
d) Increase teaching and learning quality and efficiency *4)* Personal data archives (PDAs), *e.g.* all used study materials	What is learned in each class becomes more interconnected, generalisable, integrated longitudinal knowledge	Self-guided discovery	Teachers cognisant of students building PDAs, may alter how information is offered	Infrastructure decisions (*e.g.* distribution of software and standard formats)	Staff may prepare materials more suited for PDAs, and, may approach students more holistically by accessing PDAs	Learning efficiency, *e.g.* discovery of cross-relations in ones own work	Student possessed machines required
e) Improve access to information information services, *e.g.* course schedules/ registrations/ lecture announcements/ access to scholarly databases like libraries/ student "influenced" menu's	Data used have more ecological validity which may be a desirable educational goal	Level of abstraction may be manipulated as an educational strategy	Data are supplied electronically rather than on paper	Constantly upgrading infrastructure Database client server facilities Strategies, *e.g.* multi-platform, access through Internet, proprietary and costs issues Automatic searches service (KNOWBOTS)	Maybe social pressure to use it because students may know more. Must coach students how to filter and select information	Danger overload of information Efficiency gain in literature search based papers. Discovery of cross-relations in disciplines. Knowledge about courses across the country/world	Necessary: each student passworded database access

IMPACT ON COURSE DESIGN							
IT Potentials	Educational Goals	Educational Strategies	Modes of Delivery	Institutional Impact	Impact Staff	Impact Student	Needed Infrastructure
f) Increase communication e-mail/ conferencing	E-mail and conferencing might be integrated in courses. See above	The increase in interactions might result in more student interest driven tailoring of educational environments	Teachers and students can co-locate in cyberspace, become more freed from being physically co-present	Constantly upgrading infrastructure Simple e-mail and conferencing system with good management e-mail and conferencing without limits	Lower threshold for student access Often asked questions may determine emphasised topics in lectures Might stimulate teacher to play the model of the real scientist	Huge social consequences potential for formation of specialised conference across institutions Collaborative learning	Home computer complete time independency
g) Increase freedom of studying-planning *1)* independency of time and location	n.a.	Students better encouraged to become independent learners	n.a.	Accessibility of public facilities	Few impact	Customise (time and location)	Home computer complete time independency
h) Increase freedom of studying-planning *2)* "Computerised" exams or self-tests – more generally, new student assessment paradigms	At least sequencing of parts of the curriculum have to be reconsidered in order to profit from early exam-taking Test/exams give also indication if educational goal is reached	Test/exams may be used as "advanced organisers for a course (it becomes clearer what the goal of the course will be)	n.a.	Security issues Privacy issues of student history Might increase overall throughput due to automated advanced placement tests	Produce larger generative item banks Tailor assignments according to student history	Customise (time and location) potentially gets automatic study advice Shifts responsibility to student	Real exams (not from home) Self-test with study advice from anywhere
i) Increase computer proficiency. IT as a tool for all	Achieves goal of "computer literacy"	n.a.	n.a.	Political. Institutional profile	Might change contents and style of teaching	Better employment opportunities	1 to 1 is preferable

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IMPACT ON COURSE DESIGN							
IT Potentials	Educational Goals	Educational Strategies	Modes of Delivery	Institutional Impact	Impact Staff	Impact Student	Needed infrastructure
j) Increase virtual mobility of students and faculties	n.a.	n.a.	Delivery through network or by distribution of storage media	Balance credit (money + credit hours) system between institutions. Reduced reliance on buildings	Requires CAL modules (see above) Increases exposure to competition	Reduced commuting. More diversity	Student owned computing is not necessary
k) Increase competitiveness of institution	Maybe	n.a.	n.a.	Policy decisions on role of IT and student possessed computing Return on investment - good students, good staff and more money	Commitment to respective policy	Match personal aspirations with the institutional mission	Student possessed computing as component of image

IMPACT ON COURSE DESIGN							
IT Potentials	Educational Goals	Educational Strategies	Modes of Delivery	Institutional Impact	Impact Staff	Impact Student	Needed infrastructure
1) Dartmouth experience (actual -- network and personal computer homogeneous and saturated community of users -- all students, staff, and employees, within a relatively sophisticated IT infrastructure)	Goals have not changed although the oft unchallenged general educational goal of greater student "computer literacy" has been well served	Largely directly unaffected, but with small but notable number of "faculty champions" of IT in teaching	Largely directly unaffected except few notable exceptions, although the general infrastructure has provided digital means of communication that to some degree have replaced traditional means, and have greatly improved information exchanges, retrievals, and recordings	Must constantly upgrade infrastructure Simple e-mail and conferencing system with good management Client/server access to administrative and scholarly databases Handle demand for public sites -- desire for a social milieu Institutional reputation in IT becomes a tangible asset to be maintained Implications for Information Programmes organisations, e g library/ instructional media, computing services. Drives need for a CIO and institutional IT strategy	More and easier communication with students. Pressure to use the system from growing student and colleague use	Forced to spend money. Huge social impacts. Modest direct educational impacts, other than productivity gains	Support of "student owned computing", beyond "typical" IT infrastructure, and, IT infrastructure growth and costs is driven by issues of scale when all members of a community have computers

Subsequent columns discuss the impact of actualisation of these potentials on course design, the institution as a whole, the faculty staff, and the students. Also we indicate the technological infrastructure needed to realise IT potentials, especially with regard to whether students having computers is necessary.

Impact on course design

The impact on course design can occur on three levels, most dramatically when the educational goals of a course are changed. For instance, the goal for a statistics course might change from "understanding statistical data in research papers" to "being able to infer a statistical design from the empirical question". Generally such a change implies re-evaluation of the educational strategy/method and materials. At the lowest level one might have impact just on content mode of delivery; a course might be delivered by lecture or video.

For potentials not directly related to educational issues the impact on course design is not a relevant question. There is no column for impact on curriculum -- dramatic consequences expected on the total curriculum are mentioned under "impact on the institution".

Impact on the institution

Possible consequences here are those which require the attention of the administration. This may be just steering the decision processes, for instance in selecting which courses are to be supported with computer aids. Other cases may cover decisions at the highest level. One example might be financing, such as large and long-terms costs to develop an IT infrastructure. Another example might be which career incentives, or disincentives, exist or should exist for staff members who pursue IT on behalf of teaching, perhaps as domain experts for the production of computer-based materials.

Impact on staff

IT may impact how staff teach. It has been repeatedly shown that efficient CAL (see Kulic and Kulic, 1991) perhaps augmented by discussion groups, can successfully replace valuable lecture time. More powerfully, IT can enhance what some of the best teachers already know they must do, *i.e.* create environments which lead students down "the path of least resistance" toward knowledge and life-long learning strategies. (see Impact on Students below). How IT may affect one's scholarly behaviour is mentioned here, but elaborated elsewhere in this report.

Impact on students

Both the learning and social behaviours of students are affected by IT, and in fact, distinctions between "the cognitive student" and "the social student" when considering the academic role of IT may be detrimental. A student brings to any situation three selves: cognitive, emotional, and social. The best teachers have been aware of this for thousands of years. Rather than standing like pretentious priests at podiums, they construct and facilitate learning environments, both physically and socially, within which a student's performance is enhanced. For example, rather than simply lecturing, information is presented in different modalities with novelty. Socio/emotional

impacts, outlines and "the big picture" of a course are initially presented and updated, small working groups are formed and reformed, etc. IT can obviously bring many benefits to constructing learning environments and immersing students (and staff) in them, far beyond what are now traditional IT products, such as drill and practice programmes and overly specific and isolated courseware tutorial.

Needed infrastructure

In this column is indicated how relevant the student possession of computers is. Also it can be seen if a less computer intensive approach for instance with public facilities would do.

Commentary on information technology potentials

Education for an ever changing society

It has been claimed that computers, especially the new wave of multimedia workstations are "the" solution for preparing students for a rapidly changing society. Today's problems will be solved by tomorrow's knowledge, be it procedural or declarative. Students, tomorrow's problem solvers, must acquire effective problem-solving strategies, not simply knowledge of the way the world appears to teachers. The solution, easy to state, is to shift the focus of learning from soon obsolete content to flexible techniques by which people can generate new knowledge. Giving students knowledge acquisition strategies is an optimal way to prepare them for ever changing society. IT is an obvious choice for a student's repertoire of learning tools -- rapid change generates massive amounts of information, which must be accessed, analysed, reformulated, and communicated in order to derive new knowledge and solutions. A direct implication is that educational goals drastically change. Students have to learn meta-skills, not only for a single course but for all courses -- most of the curriculum has to be revised!

It is believed that a more active learner is needed. Educational strategy shifts from root learning to discovery learning. Educational research shows however that completely unguided discovery learning is inefficient even for the acquisition of meta-skills (see Lavio and Good, 1988). Educational strategy will be one of guided discovery in which the guidance is gradually taken away.

Obviously, this will affect the institution, the staff, and the students heavily. For instance the investment in the necessary infrastructure of networked distributed multimedia machines for all is presently beyond any institutional budgets. Staff will have to participate intensively in the design and development of these multimedia "discovery" environments so that students will learn that they can not passively absorb knowledge and attest to it through material regurgitation.

At present it is felt unrealistic to further predict possible impact. This position may change in a few years, as specific demands on society change, and as IT cost-benefit perspectives change, for instance, when powerful workstations become as cheap or cheaper than televisions or stereo equipment.

Increase teaching and learning quality

- Computer-Assisted Learning

Courseware is used here as a term to describe software that partly or completely takes over the role of the teacher for a specific, sometimes very limited, educational goal. It may vary widely in quality. Empirical research consistently shows that computer-aided learning using "courseware" results in better student performance than one-to-many lecturing (Bloom, 1984).

It is generally accepted that a serious investment has to be made in order to produce reasonable quality courseware. The related production costs, the diversity of platforms, the pace with which the software becomes obsolete (not in the educational, but in the technical sense) -- all are factors that negatively influence the introduction of courseware on a wider scale. On top of these there is also the "not invented here" syndrome which results in a very small market. Most successful 'Courseware' has resulted either from some research project or individuals who invest lots of time into its development; in other words in situations that tend to obscure the real production costs.

There are a number of technical developments which might reduce considerably the production costs and result in platform independent products. For instance, new platform-independent authoring environments which come with pedagogic shells help to develop effective courseware in a fraction of today's development times. Such products have the potential for a larger market and hence a longer lifetime. However it is felt that without further incentives from the institutions for staff members to participate in the development of courseware (Darby, 1992) and/or to use courseware (even if not invented here) the future for computer assisted learning by courseware in higher education looks rather gloomy. Incentives are necessary because of the moderate esteem that can be gained from investment of time in courseware production. One scheme which might be possible is to consider the education given through and by a computer as education given by the staff members who participated in the production. Thus their original time investment would be compensated by a reduced educational load once the courseware is in operation and consequently more time of the particular staff members can be dedicated to research and scholarship.

- Computerised exercises

Drill and practice type of courseware might be developed in order to provide students basic knowledge or skills which are a prerequisite for academic teaching. For instance students in Chinese have to learn the character-set. This type of knowledge can be taught by Drill and Practice and can hardly be seen as academic teaching. Drill and Practice courseware, augmented with some simple form of mastery learning strategy, is not very time-intensive to produce and if enough attention is paid to the interface and to motivating aspects of the environment they still can be useful learning devices. These exercises are often not seen as real courseware because diagnostic power and built in educational strategies are not always evident. They might however replace working classes where a teacher walks around looking over the shoulder of the student.

The production costs of these computerised exercises are low, especially if some templates and a general presentation framework is already available. Computerised exercises have been the most successful form of computer assisted learning at several institutions (Ellis, 1990).

- Administration and operation of assignments

Here the teacher might mail one student or a group of students a problem to solve. The problem is accompanied by the needed software tools which are necessary to solve the problem, or an indication where to find them on the network.

For instance the question might be what will be the effect of some filter on some specific signal. Or better what type of filter is needed to get a target signal out of a source signal. The question is then accompanied by the a tool which might simulate filters and an oscilloscope. And of course with an appropriate database.

The idea behind these assignments may be to have the students discover the implicit knowledge themselves. The effect of the e-mail distribution is often that the student feels freer to engage in dialogue with the teacher. A form of collaborative research is triggered by having the (larger) assignments directed at groups of students.

- Personal Data Archives

These can be developed if students have their notes and other study materials at their disposal in electronic form. They are able to discover relations across courses which otherwise may escape them. Assignments can be given to specifically search for these type of relations in order to integrate pieces of knowledge in a larger whole. This form of "multiple perspective" learning is generally seen as resulting in a deeper understanding of the subject matter (Moyse, 1989). The staff members might be forced to prepare material in a form suitable for a personal data archive (PDA) and the institution might provide tools to explore free format databases.

Improve Access to information services

With the client-server approach one can make the handling of "centrally" stored information much easier, especially in universities with many different kinds of computers.

Client-server architectures permit the divorcing of specific rules of access to servers from the user. As the actual presentation of the material is separated from the information material itself one can, and should, integrate this presentation on the different types of platforms. The same material should be presented "Mac-like" on Macintoshes, "Windows-like" on DOS machines and "Motif-like" on workstations. This makes users concentrate on the material itself. Thus it can be used more effectively in a student situation.

Aside from centralised databases used for administration of housing, employment, money transference and crediting of students, one can discriminate between four types of databases. The different databases can either support the staff, the students or both categories. Different databases will have different natural information owners. It could be the central body of the university, the different faculty or schools, a department, or perhaps one or a group of teachers or students in different arrangements. The four types are described as:

– Databases easing the administration of courses;

- Databases connected to a specific course;

- Databases connected to student education as a whole;

- Databases of a social type.

One type of information put into the databases is related to the "administration" of courses, grants, credits and so on. The other type of information is the information one usually finds in printed form in libraries or faculties.

- Administrative databases

Centrally owned information would be administered by the corporate body -- and would contain materials that now are handed out as booklets or papers. Examples are the description of the university, minutes of meetings, telephone directory and other official statements usually supplied by an information office.

School and departmental owned databases will contain materials such as descriptions, information and schedules of courses. Putting information in a database instead of printing paper and distributing in the right quantities to the right places makes it much easier for the institute, and it puts more responsibility on the student. At the same time, because there is one mechanism through which access is provided, it makes it much easier for the student to get hold of information. Given the proper search mechanism the student can get information on courses given next semester on Wednesday mornings. This implies a search engine which can locate data by specific topic, time period and/or keyword. Even databases with very limited search mechanisms like the Shareware product GOPHER can be useful, although the popularity of such products might be short-lived if the sophistication of the search engine does not increase.

Much administrative work for courses and exams can be automated with a forced "electronic" registration, to the benefit of the institute as well as the student. Easy and fast access to this type of information stresses the need for up-to-dateness by the information providers -- one much more easily accepts old information on a piece of paper than in an electronically stored database.

- Learning-related databases

These type of databases are typically "owned" by the library, the school/department or the course teacher. Students may also be personal owners of such a type of database (see "Personal Data Archive -- PDA" above). Information in databases related to a specific course are "owned" by the teacher of the course. In these databases there will be teaching and learning material, seminar programmes, class lists, list of projects, etc.

- Library-type databases

The major impact on teaching/learning can come from "in project embedded" usage of this type of database. It makes it possible for students to behave as active learners, more like researchers. Information can be put together in new ways not even thought of by the teacher. The teaching role becomes more like a discussion partner and coach and less as a lecturer. This role puts higher demands on the teacher as it requires thorough preparation to coach student to ensure they do not drown in a flood of information! It also makes the teaching more interesting and stimulating, as the

closed teaching mechanism is replaced with a more open ended one, in which investigation and conclusion are less predictable. For the learning to be effective in using databases, they should be as accessible as ordinary books. The student should preferably have access to a personal computer to take where ever required.

- Social information databases

Such a database will contain material of different types often operated by the students themselves.

Improve access to licensing and security

One has to negotiate hard with the database selling companies in order to get the right type of licences at the right price. Licences must be constructed in such a way that the members of, and students at, the university can use databases containing material from the institute in a way dictated by the learning situation and not by the database selling company. Even today some of the biggest database manager companies have licence agreements which make it impossible to implement a real client-server database using any other network than an isolated local network.

Control of access should only be implemented on a minimum of "administrative" databases. However, because of licensing requirements one will probably have to have some sort of volume related access control, where the number of simultaneous users is limited.

Increase the communication

From the Dartmouth experience (see below) it can be concluded that the availability of e-mail and conferencing will have a dramatic impact on the communication within an institution. Although the impact is mostly social, there are a few potentials with educational consequences. When e-mail is easily accessible from within some computer assisted learning environment the questions that arise can be communicated directly to the responsible teacher. Of course, the same holds for computer distributed and computer intensive assignments. This might result in individual replies by the teacher who then plays the role of co-experimenter (by not giving answers straight-away). Another action of the teacher may be to have a face to face meeting in order to discuss recurrent problems.

Although it is hardly seen in the practice of Dartmouth, electronic conferencing can be used for straight educational purposes. Most promising is the possibility to conference with other students/staff with shared specialised interests but living in other parts of the globe. Such a non-social use of conferencing is well-spread in academic circles. Specific measures, like giving credits, might stimulate students to establish non-social conferences which discuss specialised subjects.

Increase freedom of studying and planning

- Personalised study portfolios

Several implementations of IT might result in greater freedom for students to plan their study and to select from a more diverse set of courses. To accomplish this goal institutions should publish a description of their courses on the network. If some standardisation between institutions can be agreed upon, it will be possible for students to search for courses that suit their needs not only within their own institution but also across the country. This can be achieved using, for instance, SQL (structured query language -- a standard way of requesting data from a database) servers and a minimal set of fields (like "title", "teachers", "time/dates", "short description of content").

Thus it becomes possible for students to combine courses at different institutions into a tailored study programme. If the institutions are within reasonable distance this might be feasible even when the courses are not delivered through the computer.

In order to allow for this type of "shopping" around there should be consensus between institutions about the credits that should be given to a course. Also if courses require a certain entrance level it is necessary to specify this in a institution-independent way.

- Computerised examinations and academic exercises

The introduction of computerised exams might have two educational benefits. Students can take a self-test at any time getting direct feedback on their progress towards the educational goal. Even if they test themselves very early this may have the benefit for the student that they get a more concrete feeling for what the goals of the course are and if these goals are congruent with those of the student.

Multiple choice format tests enable students to take an exam when they are ready, rather than at a set pace. Given a proper sequencing of course modules this might enable them to proceed faster through the study resulting in a better throughput of students. This approach can also be used for advanced placement testing again with similar effects for the institution.

It has been found empirically that students who perform well if items are presented in context might get lost when the very same item is offered out of context (Säljö and Wyndhamm, 1988, 1990, and in press).

The second benefit in the table requires some more elaborate feedback mechanism than just that of grading available through multiple choice tests. Itembanks have to be set up in such a way that each item has, for each response, some diagnostic mechanism which might result in a study-advice.

This form of exam or self-test differs from computerised exercising in that exam items are always presented out of context (the examinee does not know from which chapter in the study-material the item refers) while exercising mostly occurs within context. For instance, there can be exercises on the topic "correlation" in a statistics course, while in the statistics exam an item might refer to correlation as well as being an item on regression.

- Freedom to use IT resources at any time.

Of course this potential can be realised through the use of networked public facilities and it is not necessary to have students possess a computer. However many students work at times that public facilities are not accessible, or only at considerable cost.

Increase virtual mobility of students

Human mobility creates an ecological problem. At different places experiments have been underway exploring the idea of teleworking. In those experiments mobility has become virtual but remained the same in magnitude (Bierman and Valk, 1993; Hartley *et al.*, 1991).

The mobility of students has been stated elsewhere as a desirable goal. Not every institution can cover all possible topics, and Universities might try to profile themselves by offering some very high quality specialised courses. For instance the EEC has created special funds for a student mobility programme (called ERASMUS). However, these are only cost-effective if students from other institutions are attracted.

By giving the students access to larger networks their actual mobility might be reduced while their virtual mobility is drastically increased. This offers Universities the possibility to profile themselves by offering network-delivered learning.

As discussed above, students will only take remote courses if their own institution will credit them for this. So in order to actualise this virtual mobility it is not only necessary to have computer delivered learning environments but also agreements on crediting systems across the institution's boundaries.

Tele-learning

As is the case with teleworking, tele-learning (under the assumption of student owned computing) will reduce the reliance on buildings and might therefore reduce overall housing and overall accommodation costs of the institution.

There might be a small educational benefit which comes along with tele-learning. This is because the same subject matter can be taught from different perspectives (Moyse, 1989). It is known that multiple perspective teaching deepens the understanding of the subject-matter. Since similar courses from different institutions might differ in perspective and emphasis students might have access to different viewpoints and hence learn better.

Increased competitiveness

The positive effects of an institution encouraging or demanding student owned computing can be an increase in the quality of students and staff.

Students might be attracted to an institution which has a forward looking policy on IT enabling that institution to attract better quality students than one that does not. Such students may be attracted by an institution which matches their own personal aspirations with respect to IT. An institution may use the commitment to student computing as a component of the image it wishes to project to students, other institutions, commerce, industry and government. An institution which provides workstations, networks, information services and related infrastructural support is likely to be able to attract better quality staff than one that does not.

Case Study (current Dartmouth environment within the context of the table)

The Dartmouth experience

Dartmouth College is a small rural residential liberal arts "miniversity", offering, in addition to baccalaureate degrees, doctoral degrees in the physical and life sciences (including psychology), a master's degree in music, and professional schools of medicine, business, and engineering. There are 4 200 undergraduates, 1 000 graduate students, and 350 faculty in the college of arts and sciences. The professional schools are small, although the medical school is associated with a large regional hospital/clinic and veteran's hospital. Geographically, the Dartmouth campus is isolated from major population centres, and is compact, approximately one square mile, although the hospital/clinic form a separate larger campus approximately two miles from the main campus.

Dartmouth's experiences with computing began with two men, John Kemeny and Tom Kurtz, who in the early 1960's acted on their view that computing was a worthwhile adjunct teaching tool by creating BASIC and one of the first academic time-sharing systems. Their vision launched a strong computing tradition of being a pioneer in the instructional use of computing. A number of books, monographs, and papers describe the history and current state of computing at Dartmouth College, and the interested reader is strongly encouraged to obtain some of these -- what is written here is necessarily very incomplete.

Beginning in 1984, the provost (chief academic officer) succeeded in having Dartmouth "strongly recommend" to all incoming freshmen to acquire a particular personal computer. After a bidding and evaluation process, the Apple Macintosh was selected, and is still the "machine of choice" at Dartmouth today. Concomitantly, funds were committed to begin networking the entire campus, including residence halls, and funds were successfully sought to support the development of instructional software for the Macintosh, *i.e.* "courseware". The overall strategy was, to continue to the philosophy of Kemeny and Kurtz, that computing should be easy (which resulted in a homogeneous environment from the beginning) and freely accessible to all faculty, staff, and students.

Beginning in 1990, incoming freshmen were required to acquire a personal computer. Again, the Macintosh was the machine of choice, although no student is required to have a Macintosh, only to have a personal computer. Not surprisingly, however, there are fewer than ten students who have some machine other than a "Mac".

A support infrastructure continues to be built around the use of the Macintosh. Technically, in addition to a network port in literally every college building and location, a number of network services have been created, most notably, a client/server e-mail/file transfer/bulletin board programs, a large single "public" file server that serves many community information dissemination needs, and networked print spooling, which for the students, also provides free laser printing. Human support

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services were also provided, such as consulting, computer training, a store and repair shop were vastly expanded to deal with large-scale personal computer needs, and faculty were provided with the opportunity to work with professional programmers to develop "courseware".

It is important to realise that these services exist not only for the students. Also beginning in 1984, administrative staff began rapidly obtaining Macintoshes, and faculty at that time were all provided with a Macintosh.

- Impact on course design

It has been widely accepted at Dartmouth for years, as is true of many other schools, that student "computer proficiency" is a "good thing", and that tacit institutional goal has been extremely well served by the current networked computer saturated environment. It is safe to say that all or most students having a computer within even a minimal institutional IT infrastructure will achieve at least a minimal definition of computer proficiency. Without specific competency requirements however, the degree of student proficiency will vary widely, especially for those students who never or rarely encounter required computer use in courses, beyond simple requirements such as word processing. It cannot be said that Dartmouth ever decided to redesign its curriculum specifically to include IT, although over the years, that notion has held primacy in the minds of many of Dartmouth's leading and senior faculty, so that there have been specific as well as generalised infrastructure effects. Most notably, John Kemeny eventually became president, and so was an articulate and powerful proponent of IT, further ensconcing the presumed acceptability of computing. In sum, virtually all faculty and students depend on computing and network services in service of their educational activities. Relatively few faculty, perhaps 15 per cent over time, 5 per cent at any one time, have truly integrated computing into the pedagogy of their courses, although those who have have typically engaged in noteworthy efforts.

On the more general scale, "modes of delivery" have been significantly altered via existing network tools -- e-mail, the public file server, print spooling, and a number of other network services. In-classroom modes of delivery have lagged behind, in part due to lack of faculty demand, and in part due to a lack of institutional response to what demands there may be. Few classrooms are "technically equipped" with lecture devices such as CRT projectors and media peripherals, and even fewer classrooms are equipped for in-class student computing, such as a classroom with perhaps one computer per every one or two students, with teaching oriented LAN facilities.

The overall future educational strategy is contained with the philosophies and products of two ongoing projects -- Northstar and DCIS (the Dartmouth College Information System). Northstar represents Dartmouth's turning away from courseware "tutorials" and toward building instructional tools with wide applicability across domains. Northstar is a curricular oriented project, originating in the school of engineering and the physical sciences, which has developed a public cluster network of one-hundred UNIX workstations using AFS and X-windows. Although a "vendor independent" project, IBM has been the primary supporter, and most of the workstations are RS6Ks or RT's. Northstar developers have created a library of programmes which in turn may be called as routines by higher level Northstar applications. These applications are written with instruction, not research efficiency, in mind. For instance, a few Northstar applications deal with mathematics commonly taught and needed by science and engineering disciplines, and so have general applicability. A non-Northstar example is AnnoText, created by Dartmouth's Language Resource Centre. AnnoText, a

Macintosh programme, allows any text to be input, and then annotated with more text, with graphic images, with audio annotations, or with video. Media sources may be CD-ROMS, video-disks, or compressed hard-disk files, *e.g.* QuickTime.

DCIS is creating an integrated and standardised system of network clients and a master navigator application to access, and eventually allow write access, to a variety of scholarly and administrative databases. DCIS represents the philosophy and vision that information access -- where access implies the retrieval, analysis, creation, and communication of information -- is of utmost importance to scholarship and learning, and that information access will increasingly require access to digital networked information from both local and remote sources.

DCIS began by "putting a new face" on existing databases, starting with the library's on-line catalogue, which existed as a database, but with a VT100-style terminal interface. A client was written to access the on-line catalogue, and all other databases held by that particular DBMS. A number of such clients now exist and may be used separately to access groups of databases, although an application called "The Navigator" may be used as a single point of access to all clients and so to all databases. To date, there are hundreds of databases available, including the OED, various bodies of literature, and the databases of other institutions available over the Internet. Whether access is remote or local is often transparent to the user. Plans are being executed to continually add new sources of information. DCIS's "client/server" architecture also serves as a general model for changes being implemented in administrative computing at Dartmouth.

- Institutional impact

Student owned computing impacts are better considered as contributing to the impacts of having a machine and network saturated campus with a resultant voracious appetite for services. Impacts of saturation verses less penetration can be accorded to issues of scale. Financial and logistical issues of course must be attended to: software and information dissemination, standardisation, and support services, including acquisition and maintenance.

At Dartmouth, a computing store (allied with consulting services) and repair shop serve most pre and post sales needs. Consulting is provided by a group of eleven full-time professionals and a bevy of thirty to forty part-time student employees. (Students traditionally are employed in all phases of computing at Dartmouth, from machine-room operators to system software developers, and some stellar student employees have gone on to stellar careers in computing.) There are also the usual problems of financing for both individuals and the infrastructure. At Dartmouth, students spend their own money to purchase a computer, including upgrades, insurance, repairs, and software, although software costs have been minimised by the "KeyServer" which makes a large repertoire of commercial software available over the network. Faculty were recently granted a modest fund which can be used for professional support, including computing. Staff are generally provided with a computer as a necessary tool. In the early days of the network, the fee for faculty and staff was $50 to install a port and $15/month. Networking always has been and always will be free for students. Within four years, capital costs had been amortised, and individual fees were dropped for basic network service, *i.e.* AppleTalk or an RS232 port. Ethernet is currently fee based, but within a few years, Ethernet will be the base service, and so will be free to individuals. In general, the institution views computing and networking as a public utility, and treats it as a necessary expense. The degree

to which is should be an expense is of course always debatable, although as administrative computing becomes increasingly important to institutional management, the argument for a strong computing infrastructure is bolstered in ways more concrete than "better learning".

On a less tangible level, the institutional impact has been large. As mentioned, there is a strong tradition at Dartmouth for computing, so that faculty, staff, and students assume that "leading edge" computing will be part of the Dartmouth environment. (This may seem a bit ironic in that the "leading edge" environment is not wholly embraced by the faculty in terms of influencing educational goals, course design, and overall curriculum methods. On the other hand, this may say something realistic about the role of IT beyond an adjunct and supportive status within instruction.)

Finally as to institutional impact, the benefits and reputation derived from IT becomes a tangible asset: recruitment of staff and students is only helped, not hindered by the provision of good IT, especially at a non-technical school. A strong reputation for IT also helps further itself in that fund raising efforts are helped by a proven positive record. Also, once the senior management of an institution realises that a positive reputation for IT is enjoyed, or even that an institution's IT environment in some way brings a positive "return on investment", then resources for continued IT development are more ensured.

- Staff impact

In a computer saturated environment, especially if the environment is homogeneous, faculty can depend on the consistency of student IT knowledge. For instance, at Dartmouth, a faculty member might ask students simply to "obtain programme x from the file server, run it, and follow its instructions". No other directions are needed since neither the student nor faculty member need be aware of various operating systems, network addresses, etc. Further, such directions need not be given in person. Given that "everyone" is "on the network", many interactions, especially those not likely to suffer from a lack of personal contact, can be conducted electronically and free from the constraints of having to arrange times when all members of a group are supposed to be physically present.

Pressure on faculty to employ at least a minimal level of whatever IT infrastructure is present at an institution comes from peers, and more importantly, from students, who by themselves will increasingly adopt IT technology into their lives, making it quickly routine and second-nature, just as we no longer consider automobiles, telephones, televisions, and so on to be marvels of technology. Habituation to novel stimuli, a common trait of most organisms, takes place with IT technology, and since this trait seems to be stronger in youth, students lead the way in making IT routine. At Dartmouth, student and faculty surveys reveal what may be "common sense" -- while Dartmouth has not redesigned its curriculum around IT, everyone participates in it to a significant degree. One might ask, not only about "staff impact" but of "student impact" as well, if there would be "true losses" rather than just inconveniences if IT "went away". Although proof that there would be a "true loss" is difficult, experientially and anecdotally the question is akin to asking if the quality of life would suffer without automobiles -- after all, couldn't we still get to the places we really wanted to get to? Dartmouth is perhaps a concrete example of the fact that technology, in this case IT, is a cultural extension of mankind's evolution, and cannot be "removed".

- Student impact

The effects at Dartmouth of immersing students into a rich IT environment are a conundrum, although this is perhaps an artefact of the current state of IT at Dartmouth. On the one hand, as with staff, all students have a networked machine, and it is doubtful that few if any would easily give it up. Alternately, although students will anecdotally attest to the importance of IT to their education, simpler, *i.e.* less than scientific, assessments show that degrees of use of IT do not seem correlated with objective measures such as grades, or even self-reports by students taking the same class who either did or did not use IT specifically in service of that class. In sum, students at Dartmouth have thoroughly embraced IT, vehemently demand it, and proudly speak of it in comparison to sister institutions. Yet, Dartmouth cannot claim that its IT environment makes it a "better school" than comparable institutions that perhaps have a "lesser" IT environment.

- Needed infrastructure

Assuming an institution is engaged in providing an ongoing IT environment, then the issue of student owned computing becomes one of issues of scale, although naturally there are support issues specific to sub-populations. For instance, there is a difference between providing an e-mail system for 100 people verses 10,000 people, *i.e.* solutions to the former and latter may be totally different! At Dartmouth, the issue was EOC, "everyone owned computing." This caused the institution to create many of its own computing and networking solutions, since commercial solutions at that time did not scale to Dartmouth's needs.

Conclusions

For an institution to consider how to provide an optimal information infrastructure it should consider its goals and mission, the roles that IT might provide, the support services needed to use IT in service of goals and mission, and the start-up and ongoing costs, including opportunity costs. An IT infrastructure does not exist for its own sake, but is derived from and constructed to enable the academic mission of the institution. Within an institution's consideration of IT, the option of encouraging or requiring all students to have a computer should also be considered. The table presents various aspects of this conclusion. Interestingly, it argues more for the desirability of an IT infrastructure than for all students to have a computer. Whilst all students having a computer is perhaps an economic luxury, it is seen as a benefit to an institution's academic mission.

2. Resourcing issues

Institutional strategies to encourage student owned computing

There is a range of strategies which an institution may adopt in order to facilitate the ownership of or access to personal computing facilities for students. A number of these are considered below. (Note: throughout this chapter a number of assumptions are made. One of these is that an undergraduate course is of four years' duration. Countries where this is not the case need to consider how such a difference might affect the assumptions made here.)

Ease the initial purchase cost

Institutions may choose to reduce the direct cost to a student and hence encourage ownership by a wide range of approaches. Some possible strategies are given below.

Institutions may arrange a loan scheme to enable students to meet the cost of purchasing equipment and software. This may take the form of a commercial loan which students without collateral may find difficult to arrange themselves, or it may take the form of an interest free loan financed by the university. Another approach is to introduce a leasing scheme where ownership of the equipment gradually transfers to the student.

Universities are in an excellent position to ensure that students are able to purchase equipment and software at prices below the commercial market level either through educational discount schemes or by the university purchasing in bulk and passing on the savings to their students. It should be noted however, that in some countries the differential between educational prices and industrial prices is rapidly decreasing. In terms of software this usually means purchasing site licences or purchasing in bulk. Some universities provide the required software free to students, particularly if that software has been generated within the university or by some other body that does not charge for its software. The position with regard to site licences and how they apply to students with machines that are held off-campus depends on negotiations with specific software suppliers.

Re-cycle equipment

Some institutions have arranged a buy-back option so that students are able to recover some of the capital cost of their equipment and software at the end of the course. This leaves the university with the problem of what to do with used and often out-of-date technology. Such a policy could be linked to offering students used equipment when they come to the university as an alternative to purchasing new equipment. Such a policy can be made to work where as students progress through their courses they are required to upgrade their systems. In such a situation one approach is for students to sell their starter-level machines to students in earlier years of the course and then purchase the more advanced machine either from students who have completed the course or as a new machine.

Loan equipment

An alternative to student owned computing is the provision of computers by the institution to their students on a loan basis which might well include upgrading them at various points in the course. There are a number of reasons why such an approach might be attractive to a university. In some countries it is possible to purchase equipment at discounted prices such that after one year it is possible to sell that equipment on the open market at a price that enables the university to replace the equipment it has sold with more powerful equipment without spending extra money. In this way it is possible to overcome the problem of having a constant supply of four year old technology being returned by students leaving. It is also possible to set up schemes whereby students are given the opportunity to purchase the four year old equipment when they have completed the course thus once again resolving the problem of what to do with old technology. Although the equipment is old, since the students have used it for four years and are comfortable with it they may well be inclined to purchase it at an appropriate price which reflects its age. Another reason why a university or department might consider loaning machines to students is to overcome a shortage of space. Each

workplace which involves a computer takes around $3m^2$. The cost of creating sufficient space for a cluster of machines may well exceed the cost of providing a machine for each student who is to use that cluster. Obviously, there are hybrid schemes where costs are shared between university and student in a variety of ways and proportions.

Data communications

On the communication side there are a number of actions a university can make in order to make ownership more attractive to students. Most universities rely on a mixture of university provided accommodation and private sector accommodation to house their students whilst they are studying (some countries provide no university accommodation at all). The university can provide links to the campus network to all its own accommodation even to the level of a link for each resident. Such facilities imply that communication costs to the student are zero. For those students who are in non-university accommodation, such a provision is unlikely (although with the introduction of widespread cable TV it may be possible for the university to provide such links). Where students need to connect to the campus network from non-university locations the usual solution is to make use of the public telephone system using modems. There are three basic costs associated with this form of communication. There is a capital cost associated with the purchase of a modem attached to the student's computer (there is also a requirement for the university to provide modems at the network end), there is the cost of installation and subsequent rental of a phone line, and there is the cost of making calls on the phone line to make connection to the campus network. The university can address such costs in a variety of ways.

The modem costs can be dealt with using any of the ways discussed above for the basic computer and indeed may well be bundled in with the computer at initial purchase time or be regarded as one of the necessary upgrades required during the period of study. The university may be in a position to negotiate with the telephone company to reduce installation and rental charges for its students or to make use of other carriers such as cable TV companies who may offer more attractive prices. Many universities operate a call-back system for dial-up services in order to increase the security of their services. Under this arrangement, a student makes a brief call to the network to establish their identity; the link is then broken and call charges to the student terminate. The network then calls the student using the telephone number of the student's modem and from that point on the call charges are carried by the university.

Printing

One of the costs faced by students with their own computers is that of printing. Universities can choose to recover the costs associated with this in a variety of ways or indeed to not pass on such costs to their students in a direct way. If students are encouraged or obliged to purchase printers then the financial arrangements that can be made to assist such purchases are as discussed above. In terms of the direct cost of printing such as paper and ribbons or cartridges the university may provide these items freely within the teaching accommodation and/or the residential accommodation. It may choose to offer free printing for low quality output using such devices as dot-matrix printers or line-printers but charge for quality output such as from laser printers.

Maintenance

Many universities have internal maintenance and repair facilities for personal computers. In such circumstances it would be possible to offer free or subsidised maintenance and repair services to students. Where the university uses external services it may be in a position to negotiate a better price from such suppliers on the basis of a greater volume of activity for the external company to the advantage of both the students and the university.

Institutional infrastructure

Many advantages arising from such things as bulk purchases and central maintenance are often combined into a central service within the university which may well then offer these services to the outside world as an income generation activity which can be used to offer students further services or reduced charges for the services they receive from the university.

Fundamental to the concept of student owned computing is the need for the university to provide a range of electronic services to their students (and staff) which adds real value to the ownership of personal computers (and appropriate communication facilities to connect to the campus network). Such an approach, sometimes called the electronic campus, is one of the major costs to the university. It is also something which will require a major culture change within the university if the full benefits are to be achieved.

Cost of individual ownership

The cost of introducing student owned computing at an institution can be broken down into those costs that might fall on students and those that could fall on the institution. Almost all the identified costs itemised here as attributable to students could be borne by the institution. This is dependent upon institutional policy. The following list of items can be identified as possible costs for students.

The basic computer together with its operating software, a basic multi-application package (*e.g.* Works -- the term "works" is used as a generic name for packages which provide a combination of applications such as wordprocessing, spreadsheet, database and communications) and a graphical user interface. It is interesting to note that although it is claimed that hardware costs are reducing, two factors are at work which mean that this reduction is not necessarily available to the student. Firstly, what is reducing is the cost of power. In order to ensure their income is maintained, manufacturers are delivering more power for the same price rather than reducing the cost of the boxes they sell. Secondly, the price of a reasonable entry level machine is dictated by industry standards since this is the dominant market. As applications developed for industry become more sophisticated they demand more power. Hence the entry level machines are increasing in power. This has a potential advantage in that the uses to which student owned computing can be put are less likely to be limited by low-power machines. It is worth noting that the cost of the basic package envisaged is still relatively high in relation to income and certainly very high relative to student income. As more mature students enter higher education, often taking a substantial reduction in income to do so, the extra burden of computer purchase may be too daunting. Although cheap, low power machines are available, for a

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variety of reasons (including their inability to run certain software, a poor or expensive upgrade path and poor networking abilities) they are not a good route to take and it would be irresponsible of universities to encourage student purchase of unsuitable machines.

If the availability of student owned computing is being relied on by students and staff it is essential that machines are kept operational. The cost of hardware maintenance once the machine comes out of warranty will need to be arranged and co-ordinated by the institution but the cost could be regarded as something to be borne by the student.

Since computers are to be kept off site it is important that students insure their machines in order that they are not deprived of a machine were it to be stolen or damaged. Institutions should strongly encourage students to effect insurance and in the case where students are resident on university property may insist on such insurance.

Various software packages, including such things as Works and specialist teaching packages can be made available at greatly reduced cost if purchased through a site licensing arrangement (such an arrangement also reduces the cost of software required by staff such as authoring and presentation packages). However, making manuals available to students can be expensive.

Considering the changes that are taking place in software technology, with regular improvements to functionality and a consequent increase in the memory required to run such software, together with the need to make use of more complex software products in later years, one would expect a student machine to require a memory upgrade at various points during the course. On a four year course, one would expect the memory size to increase four-fold over the initial configuration. In addition, new versions of the software would need to be purchased on a regular (annual) basis. There is a trade-off to be made by an institution concerning upgrading software to keep pace with the latest releases of software products used by that institution. On the one hand, to replace old software by the latest release is a considerable cost both for the institution and for its students. However, in so doing, the support costs for the institution are kept to a minimum since only one version of each item of supported software needs support. By not purchasing replacement software the support required will span many versions of the software and in particular, support for complex sets of interacting software systems will be required. As an example, Dartmouth College currently supports five major versions (and many sub versions of each major version) of the Macintosh operating system.

Students will need to print material generated on their personal machine. This can be paid for either by purchasing the service from the university or by providing a personal printer. Either way there are consumable costs to be paid for. This will include such things as modems, cables and the rental and installation cost of a phone line. For those students who are not accommodated in university residences there may well be additional costs associated with the provision of communication hardware to enable these students to connect into the campus network from their own premises.

The recurrent costs associated with student owned computing includes consumables such as floppy discs, papers and ribbons and costs incurred with the telephone company (which may be offset by reduced travel costs).

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Taking all these into account it is possible to build a simple model for the costs associated with student owned computing. The model is based on a four year course and taking the price of the basic computer and software as 100 units.

	Min.	Max.
Basic unit	100	100
Communication hardware	10	15
Maintenance and Insurance	15	20
Specialist software	30	35
Upgrades to h/w and s/w	35	40
Printer	10	50
Consumables	3	5
Phone calls	5	25
Total	208	290

Thus the cost of student owned computing is somewhere between two and three times the initial cost of the basic computer and its software. It is essential that students and the institution are aware of the costs and the benefits from day one.

Cost implications for the institution

Student ownership of computers is frequently looked upon as a means of transferring the cost of computers from the institution to the student. However, even if measures are not taken by the institution to ameliorate or share these costs, there are still some substantial cost implications for the institution. Many of the figures are quite substantial, but most are not consequences only of student-owned computing, but would be incurred in any event. Furthermore, they will significantly differ from institution to institution. Nevertheless, they indicate the order of magnitude of the costs that many institutions are now facing.

- The network

The most significant implication for the institution is the need for a substantial network. In most cases, institutions will already have a suitable network in place, but it will need enhancing in certain respects to take account of the needs of students with their own computers.

Students will need access to the institution network for a variety of reasons, as discussed elsewhere. Amongst these are the need to down-load data for assignments or lecture hand-outs, the need to communicate with their peers and with the teaching staff, and the need to access a wide variety of information, such as the library on-line catalogue.

The institutional requirements, like the students', will vary substantially depending on the particular environment of each institution. A major difference will exist, for example, between those institutions for which a substantial number of students live in university halls of residence, and those where the bulk of students are in private accommodation, remote from the institution's campus.

In the case of halls of residence, the institution will need to incorporate them into its network, by wiring up the dormitory blocks, providing sockets in each room. This will also involve local switching units at each dormitory building, and the extension of the network "backbone" to these additional buildings (in some cases crossing property boundaries, possibly so incurring the additional costs of the telephone company). The additional cost of electricity in the dormitories should also be considered, as well as the provision of additional power outlets (which may be non-trivial in some older buildings).

It may also be found necessary to equip one or more rooms on the main campus with network outlets, into which students can plug their own computers when they come onto campus. This would involve similar costs to the above.

For students remote from the main campus, in particular, those in private accommodation, there will be a need to connect to the institution's network over telephone lines. The cost to the student of this activity has been noted in the previous section. However, there will be a need for the institution to provide, or increase its provision of, dial-in phone lines and modems. An appropriate provision, depending on the amount of activity undertaken by students, could be about 10 per cent as many lines as the total number of remote students seeking access. This will involve both a capital cost and the ongoing costs of maintenance and phone rental. There will also be a need for a terminal server or equivalent, which connects the phone lines to the network which has a capital and a recurring cost component.

In some cases, the institution may introduce a "call-back" facility, either for security reasons, or in order to shift the cost of phone calls from the student to the institution. If so, there will be additional capital and maintenance costs, as well as the cost of the phone calls.

In addition to these direct costs, the increased size and complexity of the network, together with its additional traffic, will require extra human support, both for hardware and software. This might cost about one person for every 300 lines added, whether these computers are local (*i.e.* directly on the campus network) or remote.

- Institutional servers

It is almost inevitable that the existence of a large body of students with their own computers will require the institution to provide additional "servers" of a variety of kinds. The most obvious would be print servers (*i.e.* general-purpose printers that can be accessed by students' computers connected to the network). This involves various capital costs (the printers themselves, interface units, etc.), and the recurring maintenance and support costs. In addition, the institution may also choose to bear the consumables cost (paper and ribbons or toner), though these, together with a component for capital, could be recovered by some form of usage charging.

Other servers could include file servers providing bulk storage or backup and archival facilities. These also involve capital, maintenance and support costs.

- Additional institutional student computers

Perhaps surprisingly, an increase in the numbers of student-owned computers may actually increase the pressure on the institution to provide computers. This could arise if the student units were not readily portable so that when students were present at the institution they would require similar facilities to those which they had themselves, having become accustomed to, or even dependent on, using them regularly. This would be especially so if ownership had been made mandatory, and the delivery of course material, etc., oriented to take advantage of that fact. This pressure would exist even if ownership had only been recommended, else those who had not been able to acquire a computer would be unduly disadvantaged.

- General support services

Increased numbers of students owning computers will inevitably generate additional pressure on various support services, whether they be provided in an organised way, centrally by the institution, or locally by individual departments, or whether they be provided informally by the teaching staff.

A significant load is incurred by the institution with the need to administer the software required to be used by the students. This involves negotiations with suppliers, issuing copies to students, recording and controlling these copies, obtaining, checking-out and issuing updates, and the preparation, duplication and issuing of manuals. These tasks are especially burdensome with some site licences, where detailed records of all copies must be kept. They are not inconsequential even for software for which blanket copying permission has been obtained.

In addition to these administrative tasks, there will be a need to provide a general help and advice service on the use of the hardware and software.

This increased support burden will not always occur at the point of origin. For instance, as more students access local or remote information sources, the library, as the logical place for helping people to access information, will receive a share of this burden (at least, of enquiries), even if it has avoided a specific responsibility in this area.

- Retraining and reorientation of support staff

A major cost to the institution of a shift to student-owned computing may be the requirement to retrain and/or reshape the existing computing support units, such as the Computing Centre.

At the very least, staff accustomed to providing mainframe support will need to be retrained in microcomputers. At worst, some staff redundancies and major investment write-offs may be necessary. Tools used to communicate with clients will change: funding arrangements, staff job descriptions, career paths, and relationships with other units on campus.

In the past, there have been substantial investments in mainframe hardware, software, manuals, and training. It is possible that some of this may have to be written off, not to mention the purpose-built computer rooms and auxiliary plant rooms for which there may now be a reduced need. There will however be a need to accommodate server machines, communication equipment, library and administration computers.

- Equipping and training the staff

If students are to make such a substantial investment in their own computers, then it is vital that their teachers understand and exploit this technology themselves. This may require an investment on the part of the institution in equipping all relevant staff with similar units themselves, and training those staff who have not already acquired the necessary skills.

Computers supplied to staff must have a degree of compatibility with units being acquired by students (especially where staff prepare material for students to take and manipulate themselves), and must be connected to the network. These are costs which may be incurred independently of whether students are required to have their own computers, but additional pressure to complete this equipping exercise would usually be expected.

A general information technology literacy training course would require a commitment of about one week per staff member (for those with no prior skills). This may be delivered all at one time, or may be spread out and delivered on an as-needed basis. In any event, some provision for ongoing training will be required. It will also require a suitably equipped training room (incorporating the computer hardware and software chosen by the institution), properly qualified trainers, and appropriate materials.

- Information technology literacy training for students

Similar training in Information Technology literacy to that required for staff would be needed by students. In many institutions, this is considered to be a responsibility of, and therefore a cost to be borne by the institution.

This training can be provided in many ways. One way would be to set up specific central training courses, perhaps prior to the start of term/semester, in a manner similar to that undertaken for staff. These would then be open to all students who need them. Alternatively, they could be undertaken at the Departmental level, by staff trained as above, and therefore tailored to the specific needs of students of that discipline. In the final analysis, the most effective form of training would be to integrate it into the normal course work of the Department, as is standard current practice at many institutions.

Whichever method is chosen, there are not inconsiderable costs to be borne by the institution (with the last method indicated, this cost may be hidden, but may take the form of excluding other material from the curriculum). Costs per person would be similar to those required for staff training.

- Classroom presentation equipment

One of the consequences of student-owned computers is that staff will need to be in a position to demonstrate material to classes, which students may then operate on their own equipment. This would involve computers (and software) in each classroom in which presentations are to be

conducted, and projection equipment (and possibly multi-media facilities also). These are currently very expensive but would be required in many rooms. In institutions where rooms are allocated and timetabled centrally this may require many rooms to be equipped so as to ensure that those who are reliant on such facilities are able to use it.

- Multi-media laboratories

Although most computer-mediated material would be delivered on students' own computers in a student-owned computing environment, the advances in multi-media may mean that some material cannot be delivered in this way but requires specialised computers with multi-media capability.

- Information infrastructure

As has been identified elsewhere, the presence of a large cohort of students armed with their own computers would bring considerable pressure to bear on the institution to make available over the network a range of appropriate, useful and developing information and services. Some of these services are identified in the annex, and include the library catalogue on-line, access to electronic mail and bulletin boards, access to information sources relevant to their courses and the institution, and access to other specialised information sources, which may only be available remotely. This will involve the institution in additional costs through the need to mount these services if not already available and through the added load imposed on them by the larger body of student users.

The first cost comprises the necessary equipment and software to provide such an information server, as well as the computing support staff to install it and keep it operational. The more significant cost, because it is new, may well be the cost of having appropriate staff in various sections of the institution make available the required information, and keep it up-to-date. Even though much of this information may already be available in electronic form, a considerable effort is required. The second cost is similar to the cost of supporting increased network use, as discussed earlier.

- Library information services

Perhaps the most important information service to be made available over the network would be putting the various library services, including its catalogue, loans system (including inter-library loans), recall system, information services (both local and remote) on-line. In many cases, some of these may already have been accomplished, though additional costs will still be incurred by reason of the additional load imposed by the students accessing them from their own computers. If these services have not already been made available electronically, then the added pressure to do so will be very great. Implementing these will involve substantial capital and recurrent costs, though the library should be able to realise a range of consequential savings in its operational costs.

- Development of teaching and learning material

By far the most substantial cost to be borne by the institution arising from the advent of student-owned computers is the cost of preparing the teaching and learning materials (courseware) designed for delivery on or in conjunction with student computers. It should be stressed that the

hardware cost associated with computer-mediated courseware delivery is a very small component of the total cost (typically less than 10 per cent). Studies continue to yield a figure of between 50 and 100 hours of staff time per hour of courseware produced. This cost clearly needs to be analysed and described, which is now attempted.

The cost of preparation of learning material is very heavily dependent on the nature of the educational model being employed. At one end of the spectrum, the production of simple item banks and tests can be undertaken in a very inexpensive fashion. But as one moves more and more from the "behavioural" end of the learning spectrum towards the "cognitive", including simulations and other elaborate self-discovery systems, the cost rises substantially.

At its most primitive level, computer-mediated teaching material can be prepared for delivery in a classroom environment using a computer and projector in a manner similar to a conventional lecture using overhead transparencies. Even this form of delivery requires substantial equipment in each classroom, including software and other material (such as CD-ROMs and Laser discs). It also requires each teacher to have copies of the necessary software, and training in the use of the software and hardware. The time taken to prepare the material varies from the time it takes to prepare conventional overhead transparencies, to many times required for complex "live" simulations to be incorporated.

In regard to courseware which is to be delivered on computers to individual students (especially where this takes place on the students' own computers, remotely from the institution), and where more cognitive educational models are employed, the process is generally a complex, specialised and time-consuming one (and therefore costly).

Firstly, there is the equipment and facilities required to prepare the courseware. This consists often of rather more powerful versions of the computers on which the courseware is to be delivered, together with a range of more elaborate equipment, such as image scanners, graphics devices, and other multi-media production equipment. The software to accomplish the development is also rather costly. Often, this equipment is too costly to provide to each developer, but must be shared; it is then logical to locate it (or them) centrally somewhere.

Secondly, a range of support services is required if this activity is to be performed in the most cost-effective fashion possible. These would include training services in courseware development -- the art, the equipment and the software. Training in instructional design would also be required, as the medium is far less forgiving of mistakes (in content and in pedagogy) than the lecture or tutorial environment. Staff of the support unit would also provide help and advice on use of the equipment and software, especially the more costly, specialised equipment, as well as general help in the whole process of courseware development. There would also normally be a requirement to provide certain specialist skills, such as graphics design and layout, as well as educational evaluation. Lastly, some special programming skills may be called for where activities are undertaken beyond the capabilities of an authoring language that can be managed by most teaching staff.

Finally, there is the cost of the time of the teaching staff required actually to produce the courseware. At the rate of 100 hours per hour of delivered material, this would become the most significant cost of all. With proper attention to the choice of hardware and development software, and to the necessary support services, this figure can be reduced, but would still be substantial.

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Model for institutional costs

The above analysis has identified the most obvious and direct costs arising from student-ownership of computers. There may well be many other indirect costs arising from a fundamental change in the manner of delivery of teaching and learning material. For instance, if appropriate incentives are provided to staff to encourage them to prepare courseware, such as credit towards promotional opportunities, then this could be seen as a potential indirect consequential cost of student-owned computing.

As with the cost to students it is possible to build a simple model of the institutional costs. The model is based on a four year course and the price of the basic student computer and software as 100 units.

Capital costs	*Unit cost*
Wiring of dormitory blocks and provision of socket (per room)	10
Local electronic connection onto network (per room)	25
Between building connections (per room assuming 200 rooms/building) (extra costs if the halls are remote from campus)	5
Modems and switching to provide telephone access to students in private accommodation (per student)	5
Print servers	25
Other servers	5
Student computers	20
Software site licences	15
Computer and network connection, per staff members requiring it	140
Initial training, per staff member	25
Cost of multi-media labs -- per lab of 20 computers	8 000
Cost of presentation equipment -- per classroom	1 000
Library system costs -- per student	8
Courseware development equipment	5 000
Total capital cost	14 283

Annual recurrent costs	*Min.*	*Max.*
Hardware and software maintenance of dormitory network (per room), or hardware and software maintenance to support remote access		15
On-campus electricity usage (per room)		2
General support		15
Ongoing training, per staff member		10
Student training, per student (if treated as an add-on exercise)		25
Lecture presentation material, per hour of presentation	2.5	250
Courseware development support services, per student p.a.		5
Teaching staff development time per hour of courseware	2.5	250
Total recurrent costs	77.0	572

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- Disclaimer

It will be obvious in the above analysis, that the costs to institutions of student-owned computing will vary from country to country, as well as from institution to institution. Furthermore, many of these costs may well be incurred independently of whether students have their own computers or not (such as the need to have an on-line library catalogue). Each institution will have to perform its own analysis to obtain the costs relevant to it. But the above is provided as a guide and as indicative of the nature of the costs that may arise.

Issues for institutions arising from cost implications

Firstly, institutions must recognise that many of the cost (and other) implications of student-owned computing will happen, albeit more slowly, even if the institution has no policy on the matter at all! More and more students will make the unilateral decision to acquire a computer, and exert pressure on the institution to provide them with more and more electronic services. There are too many benefits for them not to do so. There are also substantial benefits for the institutions to move in this direction, so long as the process is well managed and conscious, rather than haphazard or accidental.

The following issues need to be considered by institutions:

- The need to fully explore the implications (academic, financial and social) of moving towards an electronic campus before making any decisions.

- The extent to which they will provide the appropriate infrastructure information services (*i.e.* "populate" the network). The list of possible services given in Appendix 1 is unlikely to be provided in total by any one institution. Each institution will need to identify their priority areas and provide these services.

- The extent to which they will encourage/support/require their teaching staff to develop courseware. Institutions will need to recognise that without suitable incentives to staff to prepare courseware, such development will not be sustained. Examples of such incentives are study leave time to prepare material, reduced teaching and administrative loads, recognition of this activity as a factor contributing to promotion and the provision of adequate resources (*e.g.* authoring software, multimedia hardware platforms, training, support staff).

- What/when/how to change the central computer support services (and facilities) away from being predominantly mainframe-oriented (while recognising that central administrative and library computing may still require mainframe-type support) towards being network and personal computer oriented.

- How much of the cost of student ownership to take on themselves, or to try to ameliorate. In particular, consideration of the effect that 'recommended' ownership might have on disadvantaged groups.

- The extent to which they wish to identify and quantify hidden costs.

- Recognition that some consequences will be surprises, so any attempt fully to control and contain costs or predict the social changes will inevitably be fruitless; some provision must be made for contingencies, and the funding arrangements must be flexible. In particular, the potentially enormous impact on the curriculum could have cost implications that are almost totally unpredictable.

- Recognition of the size of the investment required, and how little of it is hardware (the only visible part).

The impact on all staff, academic staff and support staff at all levels, will involve the need for training and to accept new, flexible work practices. Producing an "electronic university" will have a major impact on how the institution works. Though many of the costs have been identified in this report, this new electronic environment has many potential savings to offer in terms of efficiency across the entire institution including administrative processes, research activities and teaching and learning.

The impact on students will involve the need for training and a recognition that the study and learning processes will be strongly influenced by the electronic campus.

3. Human and social issues

Introduction

Human and social aspects are products not only of technical but also of organisational, educational and environmental interactions including information, communication and reward systems. It is assumed in this section that:

- information is freely accessible throughout the institution via an institution network of access points sufficient to satisfy demand and a rich base of servers with relevant and up-to-date information;

- computers are considered a gateway to information requiring no special knowledge to access it;

- that student owned computing has reached a "critical mass".

The analysis starts by identifying the main groups of interest and considering potential effects on these groups if they encounter student owned computing in an uncontrolled way. Some of the outcomes may be quite acceptable, whilst others could be considered poor. Example actions are identified, their rationale explained and expected improvement in the outcome is proffered together with examples of some possible side effects.

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Main groups of interest

The direct participants of the university teaching process are easily identified. Additionally, each institution requires many other professionals in support of the academic process. A list of institutional groups must include students, teachers, executives, administrators, secretarial staff, janitorial, catering and maintenance staff.

Educational institutions operate inside a larger context. National governments and agencies direct and control HEIs' potential through general funding and social policies. Other groups do not have direct power over the educational process but control or influence social conditions and expectations. Such groups will include financial, international educational and political institutions, technology manufacturers, the media and the attitudes and expectations of the general population.

There are certain groups among students (and staff) who deserve special interest because of their relatively weak position in society including those with disabilities, mature students and students with non-traditional entry qualifications and experiences.

Students

In many respects, students are not what they were. There is a drive in developed nations towards improving educational opportunity. Widening of the traditional age range, gender and social classes introduce new requirements. More students will have families and other commitments, leading to a large increase in the demand for part-time and restricted hours of attendance, with extra support needed for distance learning and asynchronous dialogue with the institution. Alongside this there will be an increasing, though unstructured, computer literacy amongst staff and students alike.

Widening student access requires reconsideration of educational material and its presentation. The level and kind of experience which mature students bring with them will enrich the institution, the range of subject interests will increase, and their life experiences will benefit their peers and teachers alike. The broadening of the kind of student in Higher Education is likely to call for increasing sophistication in the academic experience as people increasingly expect their courses to be meaningful, impressive and relevant to their prior experience.

Academic staff

Academics are justly proud of their achievements, through which their teaching methods are vindicated. Increasing numbers of students cannot be addressed by traditional methods without a correspondingly increasing number of academic staff. The finance for such a growth in many countries is not forthcoming. Not only is there an increase in workload, but there are changes to employment conditions and style of appointment. There is often an increase in staff who work between education and industry or commerce and although their additional experiences will enrich the institution they will also demand more of its facilities. This is the scenario into which IT is often introduced.

It is worth considering whether, and to what degree, teachers are, or should be seen as, leaders in the change process under discussion. There has been significantly slow adaptation to change within the teaching community. (Some have claimed it has taken a decade for sensible

adoption of overhead projection slides to be achieved.) In their defence, they are custodians of knowledge, and are responsible for passing it on with minimum risk. Their training is for consistency and repeatability, not novelty and change. This mind set is a way of explaining, for example, the resistance to sharing teaching material -- an efficiency benefit. This is usually met with variations on "not invented here", "It isn't how I do it", or "It is not as good as the way I do it".

This search to satisfy the individual ego must be acknowledged and dealt with if new teaching and learning technologies and systems are to be adopted. It is necessary to identify what emotional resistance teachers have, and to make pains to support staff through the needed adjustment towards the newer paradigm. What is beyond doubt is that the academic role must change and encouraging staff to adapt will be a major task for any institution committed to the introduction of student owned computing. As one academic put it: "The sage on the stage must become the guide on the side". Thus, it is dangerous to assume that academics will lead with revised teaching methods. If progress is to made, several methods will be required, depending on the attitude and ability of those within a teaching group. Take up within an institution will not be uniform.

Executive staff

These decision makers both make and influence investment decisions. Many of them, though widely experienced in their chosen field of expertise do not welcome personal contact with information technology. Yet, increasingly, investment decisions will require understanding and knowledge of good use of technology in order to minimise the risk of expensive mistakes.

Administrative, secretarial and other staff

This group of staff can make or break effective use of IT. Being at the cross-roads of information flows within an institution they implement executive policies and procedures, collect and dispatch information between students and staff, and provide data for central departments and funding agencies. Their activities can magnify or diminish institutional effectiveness and image. Yet, because their role is supportive their needs are often neglected.

Groups outside the institution

In this group, more than any other, individual nation states and national characteristics will have significant influence on the adoption of student owned computing. Within a given society, the generalisation of this group reflects the fact that there are many influences at work. The groups are diffuse and therefore difficult to co-ordinate. They can be deflected by "local" issues, or national "fads", which can lead to irrelevant or counter-productive measures being forced onto an institution. At worst, their opinion can be wrong, especially if not expertly advised. On the positive side, some of these groups have resources to make a difference to any outcome. The media, for example, has the ability to mould or manipulate opinion, which can be in response to institutional pressure. Thus, the effects of these outside groups must be considered seriously by an institution considering supporting student owned computing.

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General culture for information technology

Data communications has been described as helping to remove the barriers of distance and time. Increasingly, work will proceed without face to face contact. Files will be transported -- or accessed centrally and edited. Teaching material may well be held centrally for all academics to access and develop for their own use.

There are implications for all working environments, including:

- increasing dependence on technology and skills in using it;
- increasing expectation amongst peers that these skills exist in all people;
- increasing emphasis on accommodation being suited to microcomputer equipment, particularly to meet health and safety regulations;
- increasing interaction by electronic rather that physical means;
- increasing expectation of immediate communicating with colleagues regardless of the distance apart or time differential;
- increasing asynchronous working activity as people no longer have to be "at work" whilst working.

It has been claimed that knowledge is doubling with each decade since the 1960's. Traditional methods for holding, referencing and cross-referencing information are unable to cope adequately. Computer related systems have developed to receive and hold numerical and more recently textual, graphical and pictorial information. Soon, sound and video will be commonplace information which can be stored, retrieved and manipulated. Technologies have moved their focus onto retrieval mechanisms for information, incorporating attachment to remote sources. It has become the Information Age.

What is evident about the Information Age is that it creates a relationship between people and machines. The purpose of the machine is to provide people with better opportunities to access, process, and present information. However, institutions that believe that investing in technology is all that is necessary are risking a significantly reduced return on that investment.

As increasing quantities of information are being held in computer-readable form, it is necessary to have new skills to negotiate the material. It also calls for direct access to information by those needing it -- not via an intermediary such as a librarian or other "expert". This is true as much for the institutional management as for the technician; for the student as much as the professor.

It is important to identify as clearly as possible the use to which information is to be put. Considerable effort has been invested in making things look nice "because we can", without first evaluating whether that is of paramount importance. Awareness of this kind of issue can improve success in the introduction of IT. Without developing an interest in, leading to an exploitation of, skills in access to information, it will not be possible to broaden an institution into one with an information technology culture.

Many current uses of IT replicate existing practice. For example, the word processor functions like a typewriter. What is overlooked is that the typewriter operates these functions synchronously -- keying, printing and "snopake"-type editing are carried out as one operation. A computer providing word processing permits these processes to be split in time. However, unless the working practice is thought through again, the benefits offered will be minimised to just wasting less paper, improving the edit cycle and verifying spelling.

The skills required to operate IT asynchronously are complementary to, not replacements of, synchronous skills. For example, with stock market share price information, the daily paper delivers the synchronous datas, with which most would be content. IT on the other hand provides greater choice in the way information is accessed. If we want to deal in shares the information must be up-to-date. But if we are examining theoretical marketing concepts, it is the quality and the "clearness" of the presentation which is essential. The problem is to identify when the visual aspect is paramount and when the delay is critical.

The future without leadership

Before commenting on actions believed to be useful to institutions in the development of IT in support of student owned computing, it is worth considering what might happen if nothing is done.

Without co-ordinated institutional policy, managers and executives will not be concerned with their IT investment in a systematic way. Not realising that information is the key, not technology, they will usually have unclear objectives. Without clear and realistic objectives, they will expect to save money by using IT, to spend less on IT per capita year on year, and to equate greater productivity with buying equipment and software.

With no institutional agreement on goals for student owned computing there can be no consistent development plan or implementation; no ability to capitalise on other developments due to lack of standards; no compatibility between institutions.

This will lead to the inability to broaden sector-wide facilities (*e.g.* sharing material); the dominance of developments by manufacturers, and disadvantaged social groups being ignored. The role played by administrative staff as "information and communication nodes" will be overlooked, leading to a sharply decreased desire and ability to contribute to institutional goals.

On the other hand, it will provide opportunities for individual initiatives. It should be remembered however that such an approach often means that simplistic approaches will be adopted to satisfy immediate concerns, patchy developments will predominate, reducing portability and efficiency, and the role of education will tend to be confused with skills training (*e.g.* how to use a spreadsheet).

Without institutional direction, there will be an increasing diversity in the range, power and skills of equipment and software used by students, staff, departments and faculties.

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This diversity will act as a significant de-motivator, since, for example:

- One of the benefits of computer-generated material is its repeatability. Lack of consistency makes it is hard to prepare material for those with different computer experience, and to anticipate what might be needed, nor can teachers rely on a standard delivery platform.

- Pedagogic material, where developed at all, will use diverse platforms reducing generalised use. Products will not be of consistent quality.

- Lack of consistency will inhibit investment in tools to aid in the production of pedagogic material.

- Lack of consistency will discourage people from producing material for use in computer form.

- Lack of consistency removes the ability to use IT for communication.

In short, lack of consistency will discourage the development of an electronic campus.

Given there is no institutional leadership, development will be by interested parties only. The majority of academics do not have time, nor perhaps inclination, to develop skills in IT, so many see it merely as a mechanism for improved presentation. This will stunt real benefits, and keep students in the automated typewriter era. This communicates a distorted view to students, which could have serious consequences for national competitiveness in the longer term.

With the above attitude, academic leadership in IT skills and usage will be increasingly marginalised. Their influential role will diminish as students, who are increasingly educated by schools to the potential of IT, become disillusioned when faced with "old-style" academic regimes. This could impact student respect for academic competence. A downward spiral could develop in which fear of exposure by academics leads to increasing reliance on traditional methods, and they turn their back on IT, judging it "not for them", not realising information is the keyword, not technology. At the same time, students will have greater demands for support and directional guidance, which staff cannot fulfil. In turn, this increases the potential for conflict, due to frustration and unfulfilled expectations.

Amongst students and staff with no organised support system, the weak could go to the wall. Students and staff may seek to avoid computer-oriented activities within the institution. Those who are not computer literate increase their natural resistance to change. They could become excluded from being an active part of the organisation's information system, or even lose their role as they are cut out of the information flow.

Consider the following extreme scenario. Students will require more support as academics become less competent to instruct. Where will this support come from? This is a dangerous development, as it will provide the opportunity for a sub-culture to rise, based on the attitude of the most competent students. It might always be benign, though the experience with viruses, Trojan horses and hacking shows that it cannot be guaranteed. The point is that it is not controlled or managed to standards imposed by the institution. At worst, the law of the jungle could take over in

which a class of student consultants emerge. Without any controls, they could develop criminal tendencies, in which the risk of bullying, threatening or even criminal behaviour is imposed in order for the less proficient student to gain the advice needed.

Some staff will readily assume the mantle of expert, without specific management direction to do so, and without regard to their true professional role. Others will be encouraged or directed to become local experts, to have the status of "expert", without reference to their own professional skills. This is how, for example, good auditors become poor "dBase" specialists and average auditors!

Existing staff structures can be upset, and become less efficient, if duties are distributed and filled according to the computer literacy of employees instead of their real professional competence.

Suggestions to improve the effect of student owned computing

The table below identifies the goals which institutions could set for mitigating against the scenario outlined in the previous section.

4. Conclusions

Benefits

The main benefits of students having ready access to computers are to do with increasing the openness of learning, giving students the ability to exercise more choice with regard to where they study, how they study, when they study and what they study. Part of this is to do with giving students access to the rapidly growing world of electronic information and the interactive nature of much of this. In particular, the ability of students to seek information, store it, process it, reformat it, and to incorporate it into their own work. Part of it is to do with making the students more completely IT literate and to enable them to communicate with their peers, their teachers and the general community of world-wide scholars and to participate in ongoing discussions on electronic bulletin boards. Part of it is to do with the creation of their own Personal Data Archive (PDA) as a personal view of the discipline they are studying. Such a PDA can form the basis of a lifelong PDA which can grow and develop throughout their life. Part of it is to do with the ability for students to make use of the computer as a modelling tool to explore issues which would otherwise be impossible or impractical. Such simulations can be of benefit in many disciplines across the social and natural sciences, in engineering and technology as well as in the arts.

Implicit in the above is a new paradigm of learning. The student needs to be able to make sense of an ever increasing information base and to use a wide range of network services to inter-relate with peers, tutors and others in new ways. The emphasis in this meta-learning paradigm is on information not on technology. The stand alone micro-computer used for word-processing and little else is not the appropriate paradigm. Students must learn to make use of network services in the way they make use of a phone (*i.e.* they must not regard it as a barrier rather as a natural communication channel). Failure to recognise this can lead to rejection of IT by non-specialists.

If user owned computing is to succeed it must be easy to learn and use, must provide quick and easy access to useful information. There must be a critical mass of infrastructure in place to support the users, including support and training staff, equipment, software and connectivity.

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In considering the benefits one must recognise that the first order consequences of a technology are relatively easy to predict whereas the second and third order consequences as the technology becomes pervasive are less obvious yet potentially more far reaching.

Students will own computers

Students will need and want their own machines to avail themselves of the many IT services which become available not only at HEIs but elsewhere. As technology continues to become cheaper and better, the price of "end-user devices" will no longer be a barrier for students, who will look to their institution to supply an enabling infrastructure. Institutions that do so poorly may be less competitive. Support necessary to use the infrastructure advantageously must also be provided, including consulting, training for basic tool use and tool use within the individual's context. For example, teaching a mathematical student to create complex formulas in a word-processor, or a language student to efficiently conduct searches of foreign language databases. Network service applications are arrayed along a continuum from content-free to content-laden. E-mail, a prime example of a productivity tool, is content-free, whilst tools to access scholarly databases, perhaps a network client that accesses the Oxford English Dictionary, are content-laden. Institutions will need to consider which IT services they should provide and support in order to meet the needs of the community they serve.

Planning is essential

Many of the effects of student-owned computing will impact a university with or without a policy on the matter. More and more students will unilaterally acquire computers and in doing so exert a range of pressures on the institution. In particular there will be strong pressure to provide these students with more and more electronic services. There are substantial benefits for the institutions to support or encourage such a move so long as the process is well managed and conscious, rather than haphazard or accidental.

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GOAL	ACTION REQUIRED	EXPECTED OUTCOMES	POSSIBLE SIDE EFFECTS	RELATION TO OTHER ACTIONS	PREREQUISITES	ADDITIONAL NOTES
Clarify professional areas for teachers vs technical support staff	Select responsibility areas for teachers and support technicians Define priorities	Technical problems from student owned computing do not disturb the teaching	Continuous refreshment of the technical infrastructure High costs for the Institution	Modernise equipment and introduce standards	Economic means for technical support staff	
Influence expectations through better information in advance	Inform about the values and limits of student owned computing	Realistic expectations towards integrated student owned computing		Teacher development	Develop sufficient information material/method Inform the institutions staff before the students	
Provide staff training for the implications of student owned computing	Budget and support Develop courses	Raising of teacher skills and confidence Teachers stay ahead of students in use of IT Improved attitudes towards IT	Slow preparation for student owned computing Educational goals not reachable in time Too much attention paid to technical aspects in the education	Individualisation and teaching reorganised	Time and money Acceptance among teachers	
Introduce motivating activities	Inform staff about the implications of student owned computing Inform staff about the value of sharing information	Staff no longer unmotivated or resistant to student owned computing More motivation among teachers to draw benefit from student owned computing	Ideas emerge to draw benefits out of student owned computing	Teacher education and course development	Knowledge about teachers incentives Means to meet revised incentives	
	Improve the reward system to include required competence					

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GOAL	ACTION REQUIRED	EXPECTED OUTCOMES	POSSIBLE SIDE EFFECTS	RELATION TO OTHER ACTIONS	PREREQUISITES	ADDITIONAL NOTES
Take advantage of motivated individuals (teaching reorganised)	Select course parts for self paced computer mediated learning	Higher pedagogical goals for the teacher-student meetings	Less feed-back about basic knowledge acquisition to the teachers	Extra budget for teacher education and course development	Extra course development resources	
	Take advantage of less pressure on institutional resources for individual work	Less time spent for transmission of information human-human		Teacher motivating activities	Teachers motivated to educational change	
	Concentrate teacher student contact on things		Computer managed	Learning		
Modernise equipment and introduce standards	Keep institution Owned equipment at least ahead of student owned computing	Student owned computing does not take priority over institutional developments	Continuous refreshment of technical infrastructure		Economic means to keep ahead	
	Introduce standards for inter-working between student owned and institutional computing		High cost for the institution		Ability to choose standards with future value	

GOAL	ACTION REQUIRED	EXPECTED OUTCOMES	POSSIBLE SIDE EFFECTS	RELATION TO OTHER ACTIONS	PREREQUISITES	ADDITIONAL NOTES
Build peer system for student and staff coaching	Select peers and give them institutional status	Reduced fear of IT	Coaches give an information filter to feedback from students to teachers	Reorganisation of coach's time	Institutional and student approval	Do students choose to be selected or does institution select?
	Give skills training in attitudes, communication and computer skills	Weaker students improve rather than die	Rejection if bad introduction to the organisation	Teacher education	Require access to and competence with the environment to be used	The choice of reward system will bias the "volunteers"
	Publish details of the support system and ensure commitment	Diminish illiteracy of students		Expansion of the technical staff	Staff support developed -- training the trainers	Link to academic credits for students?
	Monitor and guide their contribution	Tendency for an oppressive sub-culture minimised			Appropriate social climate with rewards to balance academic load	Link to professional promotions for staff?
		Minimal delay of reward for use			Time given to coach the coaches on a regular basis	
		Improve feedback of student experience with equipment and systems				
		Improve quality and quantity of student experience by dialogue with coaches				
Redefine institutional education profile against commercial competition	Find out what commercial on-line education services do better	No threat from on-line competition for student owned computing	Possibilities for income for institution staff in related commercial developments	Teacher motivating activities	Commercial skills	
	Create related companies for this kind of service					
	Concentrate education content on other sectors					

GOAL	ACTION REQUIRED	EXPECTED OUTCOMES	POSSIBLE SIDE EFFECTS	RELATION TO OTHER ACTIONS	PREREQUISITES	ADDITIONAL NOTES
		ADDITIONAL ACTIVITIES FOR GROUPS OUTSIDE THE INSTITUTION				
Be adequately informed and advised	Make decision makers able to understand the value of investment in IT in relation to each specific interest group	Increased predictable flow of funds	True costs might frighten off potential investment		Actively co-ordinate and support sector experience and development	Must have clear, and sector-wide agreement
		Increased awareness from public	Demands for access by local communities might develop		Present as required	Must have authoritative and respected body
		Increase in understanding from decision makers			Be media conscious	
					Be an evangelist	
Construct and agree a clear set of goals and plans	Establish small task force to generate goals	A clear set of goals	Raised expectations heightening need for quick delivery		A recognition of need	
	Use discussion groups to solidify opinion	A general blueprint for their achievement	Raised awareness of IT within the community		A support for the approach	
	Circulate to institutions for comment & support	Raised awareness of educational value in institutions, local communities & others	Greater sales of equipment, software, accessories and consumables		Credibility of the task-force members	
	Conference to ratify					
	Hold annual review of progress					
	Press report for all main achievements					

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GOAL	ACTION REQUIRED	EXPECTED OUTCOMES	POSSIBLE SIDE EFFECTS	RELATION TO OTHER ACTIONS	PREREQUISITES	ADDITIONAL NOTES
Develop partnership with manufacturers and government	Sell the goal and plan	Supportive environment	Market forces will affect level of commitment from manufacturers		The preceding two goals must have been achieved	
	Gain commitment	Synergy	Changing governments may have differing priorities			
	Ensure there is something in it for all -- "win-win"	Additional outcomes from greater awareness of needs	Disadvantaged might overwhelm demand			
Publicise achievements	Utilise links with media from previous actions	More natural acceptance that IT is useful, and worth the investment	If results do not come, are not presented properly, or lack "reality", then support could drain quickly		Must have had achievements	
	Relate to particular interest groups	Greater distribution of knowledge of IT and its use	More acceptance of distance learning		Must have mechanism for promoting success	
	Focus on benefits, not costs	Students to be ambassadors for IT through positive experiences	More acceptance of Tele-working as a new way to work		Must have individuals aware of this mechanism feed in their experiences	
	Stimulate "more to come" culture					

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Institutions will need to fully explore the wide ranging financial and social implications of moving towards an electronic campus before making any decisions. The range of information services an institution will provide will of course depend on many factors within the institution. The list of possible services given elsewhere in the report is unlikely to be provided in total by any one institution: institutions will need to prioritise.

The way in which an institution will sets about developing courseware will depend on a number of factors. Without suitable incentives to staff to prepare courseware, such development will not be sustained. Study leave time to prepare material, reduced teaching and administrative loads, recognition of this activity as a factor contributing to promotion and the provision of adequate supporting resources are all ways of encouraging and sustaining such an activity.

Those who do not plan for student owned computing and do not issue guidelines to their students will be unable to cope with the plethora of equipment and software which students will have. Such a situation will lead to frustration by the students and an inability of the institution to cope.

The electronic campus

For an institution to consider how to provide an optimal information infrastructure it should consider its goals and missions, the roles that IT might provide, the support services needed to use IT in the service of goals and missions, as well as the start-up and ongoing costs, including opportunity costs. An IT infrastructure does not exist for its own sake, but is derived from and constructed to support and in some cases, enable, the academic mission of the institution. Within an institution's consideration of IT, the option of encouraging or requiring all students to have a computer should also be considered. The main body of this report argues more for the desirability of an IT infrastructure than for all students to have a computer, although all students having a computer, whilst perhaps an economic luxury, is seen as a benefit to an institution's academic mission. Moreover, in the near future it is likely that more and more students will either arrive with their own computers or acquire them during their studies.

Costs

Institutions will need to decide how much of the cost of student ownership to take on themselves, or to try to ameliorate. In particular, consideration of the effect that "recommended" ownership might have on disadvantaged groups.

Institutions need to recognise that some consequences will be surprises, so any attempt fully to control and contain costs or predict the social changes will inevitably be fruitless; some provision must be made for contingencies, and the funding arrangements must be flexible.

Institutions need to recognise the size of the investment required, and how little of it is hardware (the only visible part). The introduction of new teaching and learning processes, the training of staff and students alike in the use of the new technology and the general change in the culture required of an institution are all time consuming and expensive.

Social issues

There will be an impact on academic and support staff at all levels which will involve the need for training and for staff to accept new, flexible work practices. Producing an "electronic university" will have a major impact on how the institution works. Though many of the costs have been identified in this report, this new electronic environment has many potential savings to offer in terms of efficiency across the entire institution including administrative processes, research activities and teaching and learning.

ANNEX

THE ELECTRONIC CAMPUS

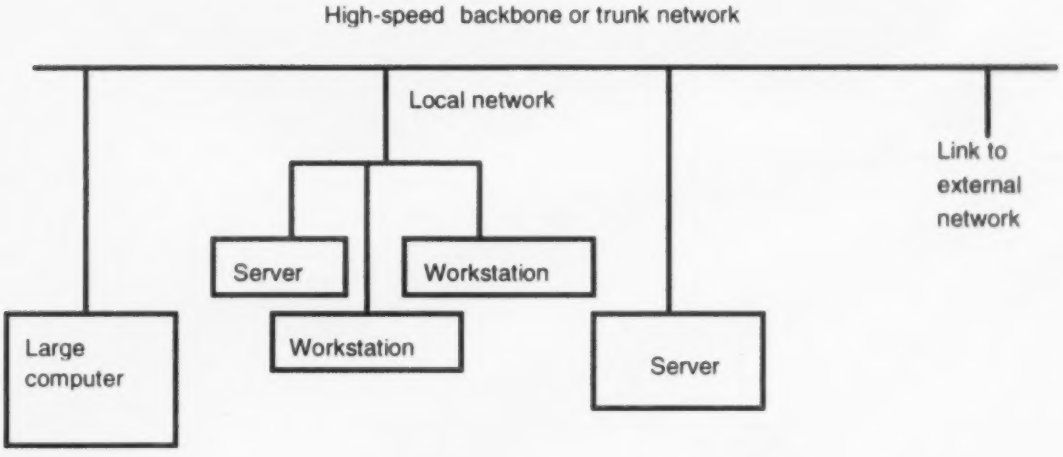
The term "electronic campus" is used to describe a situation where an institution has established an extensive computer network (or to put it another way, a network of interconnected computers). However, this can be deceiving. There are at least two important components which need to be present before it is sensible to talk of an electronic campus. Firstly, an institution needs to have established a computer network which reaches out to all or almost all parts of the institution (administration, management, teaching centres, research centres, the library, and student residences), which also reaches out to students, suppliers and other customers who are off-campus, and finally is linked to national and international networks in order to enable people in the institution to make contact with co-workers at other institutions and to be able to gain access to remote services. Secondly, the network must support a wide range of services, some within the institution and some outside the institution, which help the institution achieve its goals and mission. A partial list of possible services are given below.

In talking about a computer network it is useful to consider what kind of computers one might find connected to a network. The historical position would be the large computers used by a university to support its research activities, mid-sized computers to run its administration and perhaps a dedicated computer to run aspects of the library services. The purpose of the network in the past was to provide access from simple terminals to these large systems and to enable some transfer of information between different computer systems on the network. The services provided on the network were mainly determined by the specialised services provided by the large computers. Thus the administrative computer provided the usual administrative functions such as student records, financial control and personnel records and such a system served a small, clearly identified group within the institution (the administration). Similarly, the other machines served their own community. Only such things as the library catalogue and electronic mail could be seen as general services of value to all members of the institution's community.

Although large computers may well still exist within a university and indeed be connected to the network, the bulk of the computers that will be connected to a network will now be physically small yet often very powerful, single user workstations or personal computers. Whereas a university might count the number of large and medium-sized computers on its networks in the tens, there might be thousands of small computers on a network. It is the arrival of so many small computers, some of which will be owned by students, others by staff and others provided by the institution to support teaching, research, administration and management, which has changed the role of computer networks and given rise to the term electronic campus. In addition, there has been a trend away from large systems running many applications to smaller systems running single applications. Such systems are now called servers since they provide a clearly identified service to the community using the network. Terms such as mail server, file server, name server are used to describe systems which provide an electronic mail service, a service for storing files and a service for recording the names of people and other services on the network. This leads to a picture of a network which has three broad kinds of computers attached to it. General purpose, large and medium scale computers mainly to support research and administration; a wide variety of servers often provided on small to medium scale

computers, and user stations ranging from expensive, powerful workstations to support research and specialist activities to less powerful, cheaper personal computers such as PCs and Macintoshes. The network itself is the cables and electronics that enable all these many thousand devices and people using them to communicate one with another and with the outside world in an effective, productive and meaningful way.

A schematic of a typical campus network is given below.



Campus-wide services and information services

Listed below are a range of services and information resources which one might expect to find on a university network. They have been grouped by provider but it is recognised that such a grouping may not be that used by all institutions. The list is neither exhaustive nor prescriptive.

Centrally provided services and information:

- telephone directory;
- list of names and location of all staff;
- historical and background information about the university;
- details of its faculties, departments and committees;
- news and information about what is on;
- dates of all meetings of the governing body and its subcommittees;
- minutes of all meetings;
- job vacancies in the university;
- key reports for public comment;
- policy documents;
- university regulations;
- grant information;
- weather and traffic news;

- menus in university restaurants/cafeterias;
- travel timetables (rail, bus, air);
- on-line expense claim forms;
- access to financial information;
- access to student records;
- on-line fault reports on buildings and their fittings;
- on-line forms for a variety of information collection tasks;
- bulletin boards and electronic conferences to disseminate information and to collect ideas and opinions;
- central room availability and central timetabling information.

Provided by the library

- local catalogue;
- other university's catalogues;
- loans;
- opening hours;
- CD-ROM databases;
- inter-library loans;
- book recalls;
- book reservations;
- suggestion box;
- conditions of use;
- library news;
- access to remote information bases.

Provided by the computer centre

- user manuals;
- training course schedules;
- software and hardware availability;
- hardware and software price lists;
- special offers on hardware, software, upgrades;
- known bugs and virus information;
- availability of site licences;
- public domain software lists;
- down-loadable software;
- appropriate external bulletin boards;
- information about external databases and their access;
- conditions of use;
- centre news;
- suggestion box;
- electronic mail servers;
- print servers;
- file servers;
- academic information servers.

Provided by departments/faculties

- class lists;
- student and staff images (photographs in digital form);
- timetables;
- meetings;
- seminar programme;
- course details;
- course regulations;
- coursework specifications and deadlines;
- examination timetables;
- past examination papers;
- project details;
- grant information;
- departmental research reports;
- social activities;
- sale of second-hand books;
- lecture notes and hand-outs;
- departmental financial information;
- research student information;
- departmental software and hardware availability;
- departmental resource bookings (*e.g.* rooms, loan computers).

Provided by student support services or organisations

- news items;
- club activities;
- shared transport offers;
- health service availability;
- crèche facilities;
- counselling and other help facilities;
- sports facilities;
- careers information;
- jobs and part-time work;
- grants and other support;
- Provided by staff oganisations;
- car pool information;
- sports facilities;
- senior common room activities;
- local restaurant guide;
- jobs;
- open letters;
- union matters;
- crèche information.

Many other units or organisations may wish to provide information to an institutional electronic information service, both internal and external (such as commercial concerns providing services to the institution's community).

Many universities and other organisations (educational, non-profit and commercial) are now making a wide range of information and databases publicly available (much of it free of charge) over national and international networks. Through Wide Area Information Servers (WAIS) and other tools already available at many institutions, this information is being made available to their academic community. Sometimes this is mediated through the library or the computing centre; at other times it is accessed directly by individual academics and students.

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